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WHY WE WEREN'T PREPARED FOR THE CORONAVIRUS

NATIONAL GEOGRAPHIC

EVEREST

SPECIAL ISSUE

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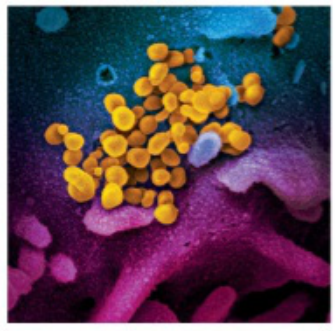

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THE COVID-19 PANDEMIC

Science-Based Coverage Is More Vital Than Ever

BY **SUSAN GOLDBERG** PHOTOGRAPH BY **DAN GIANNOPOULOS**

Photographer Dan Giannopoulos created this mosaic with 368 images of discarded disposable gloves. Around the world, managing the COVID-19 pandemic has been complicated by shortages of protective gloves, masks, and gowns.

WE PUBLISHED the first issue of *National Geographic* in October 1888. The magazine looked quite different from today's, with a plain brown cover and not a single photograph in its 98 pages.

Clearly, a lot has changed. But two things have remained constant: We have always covered science, and we've always covered the environment. "Geographic Methods in Geologic Investigation" is one headline from that first issue. "The Great Storm of March 11-14, 1888" is another.

Today we're still covering storms, especially as they grow fiercer with climate change. And we're still covering groundbreaking science—perhaps now more than ever, as we document the coronavirus that has swept across the Earth since the start of the year.

In this issue of *National Geographic,* along with our exclusive coverage of Mount Everest, there's a special report on how COVID-19 has affected everything about our lives—our health, our work, our play, our relationships. Even the highest peak on the planet hasn't been spared: Everest was closed to nearly all climbers in March.

The uncertainty surrounding this virus can be unnerving. What you *can* count on, no matter the state of the pandemic, is our commitment to covering it with factual, science-based global storytelling and authentic, on-the-ground photography. Across our platforms—print, digital, social, audio, and television—we're working to deepen understanding of this situation, with documentary photography and inspiring, actionable journalism.

One thing COVID-19 has made abundantly clear is how small our planet is—how interlinked we all are and how much we need to work together to protect Earth and its inhabitants.

This year, as National Geographic turns 132 years old, we're one of literally millions of brands competing for your time. But our yellow rectangle still means what it always has: that we are on a mission to explore, to explain, and to reveal the human journey, now and into the future. We can't do that without your support.

Thank you for reading *National Geographic.* ▯

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CORONAVIRUS

A SPECIAL REPORT
FROM NATIONAL GEOGRAPHIC

HOW THE WORLD SEES THE VIRUS

From Italy to Brazil to Russia, photographers capture intimate images of isolation.

LOOKING AT THE CRISIS FROM EVERY POSSIBLE ANGLE

IN THIS SECTION

Warnings We Ignored
The Cost of Distancing
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Water for Handwashing

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MILAN, ITALY An early hot zone of COVID-19, Italy was the first European country to order a near-total lockdown. In their apartment, photographer Camilla Ferrari and her partner noticed how images of buildings outside began to merge with scenes inside.

PHOTO: CAMILLA FERRARI

CLOCKWISE FROM TOP LEFT: **BAHIA, BRAZIL** Before the imposition of confinement rules, a man and his dog enjoy a day at the beach. **JOHANNESBURG, SOUTH AFRICA** Home gardens offer some residents a much needed escape from life within four walls. **BARCELONA, SPAIN** Exercise under lockdown requires resourcefulness, such as setting up a mini-gym on a rooftop. **SAN FRANCISCO, CALIFORNIA** Condensation on a bathroom mirror imparts a painterly haze to an inventive self-portrait.

PHOTOS: LUISA DÖRR; LINDOKUHLE SOBEKWA, MAGNUM PHOTOS; PAOLO VERZONE; DIANA MARKOSIAN

CLOCKWISE FROM TOP LEFT: **LONDON, ENGLAND** Given for Mother's Day (celebrated on March 22 in the U.K.), flowers show the passing of time. **MILAN, ITALY** A grandmother struggles with isolation—feeling alone, confused, and vulnerable. **NEW YORK, NEW YORK** Bangladeshi photographer Ismail Ferdous made the difficult decision to stay in his adopted city, capturing moments such as an apartment dweller at his window. **MOSCOW, RUSSIA** A girl finds diversions the way millions of others do, on a smartphone.

PHOTOS: OLIVIA ARTHUR, MAGNUM PHOTOS; LUCA LOCATELLI; ISMAIL FERDOUS; GUEORGUI PINKHASSOV, MAGNUM PHOTOS

NESODDTANGEN, NORWAY Boe, four, plays a shadow monster game with her mother, Anna, before bedtime. Her father, a photographer, and her mother, a doctor, were challenged to find ways of keeping Boe entertained during the early days of lockdown.

PHOTO: JONAS BENDIKSEN, MAGNUM PHOTOS

THE BACKSTORY

CIRCUMSTANCES BEYOND OUR CONTROL HAVE FORCED US APART. HOW DOES THE HUMAN SPIRIT ENDURE?

WHEN THE WORLD seems unkind, "home is the place where…they have to take you in," wrote the poet Robert Frost. But in the era of a deadly virus that requires self-isolation for weeks on end, homes have become much more than sources of comfort and familiarity. We've turned them into schools and offices, centers of entertainment, and hot spots of tension. If boredom, stress, and anxiety could be harnessed for energy, they'd power the planet.

Photographers around the globe have captured images of this strange time, when we're separated from each other by walls and windows. Seen together, the photos make us wonder, what even is a home? In a world plagued by COVID-19, the answer has increasingly become a measure of privilege. Do you have a home? Do you like being there? Are you confident you'll be able to stay?

The images also show the different ways we respond to crisis and—even more revealing—what we consider essential. Age, location, and sometimes faith tend to influence one's level of concern and feeling of vulnerability. Consider the Italian couple under self-imposed house arrest. The beachgoing Brazilians eager for time outside. Those starved of nature in urban dwellings in South Africa, New York, and Russia, who find balconies, fire escapes, anywhere at all, for gasps of wild air.

Though dread and disease cloud outlooks, there still are silver linings. Humans keep adapting; a rooftop becomes an exercise studio, and a wall a canvas for shadow dancing. When you take time to look, even dying flowers become a work of art. No one knows how long this will last, or how we'll emerge on the other side. But as we're all split apart, the least you can say is that we're doing it together. **–DANIEL STONE**

KUALA LUMPUR, MALAYSIA For normally frequent travelers like photographer Ian Teh, home is wherever you make it, and wherever loved ones are with you to wait out the storm.

PHOTO: IAN TEH

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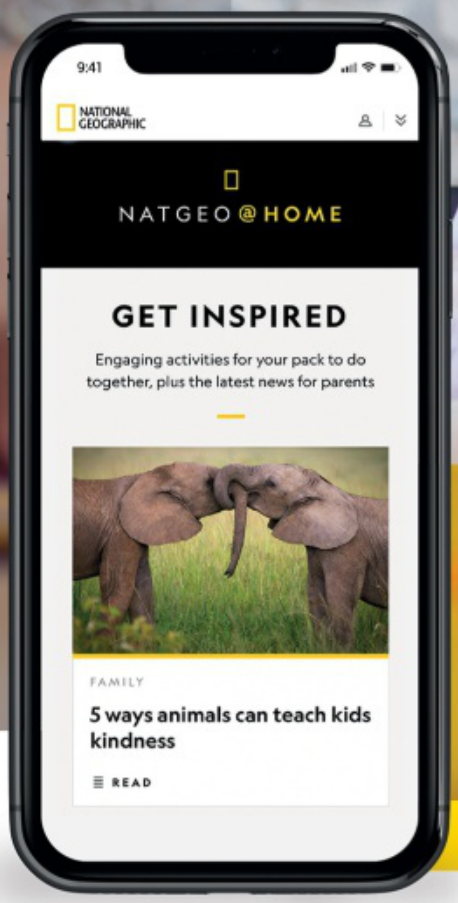

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NATIONAL GEOGRAPHIC

CORONAVIRUS

A SPECIAL REPORT FROM NATIONAL GEOGRAPHIC

JULY 2020

VOL. 238 NO. 1

Why Weren't We Ready for This Virus?

FOR DECADES THE WORLD HAS IGNORED PANDEMIC PREDICTIONS FROM THE EXPERTS. MAYBE THE CORONAVIRUS WILL CHANGE THAT.

BY **ROBIN MARANTZ HENIG**

IN THE FIRST WEEKS of the coronavirus pandemic, I couldn't bear to read about our collective early missteps. Not only because the implicit rebuke felt futile—what was the point in knowing that the grim reality we were living could have been avoided?—but because, in my case, it also felt deeply personal. Each article I read about missing the warning signs of a devastating new virus reminded me that decades ago, scientists had been worrying about that very thing, and a few science journalists were writing about their alarm. I was one of them.

When I started researching this in 1990, the term "emerging viruses" had just been coined by a young virologist, Stephen Morse. He would become the main character in my book *A Dancing Matrix,* published three years later. I described him then as an assistant professor straight out of central casting: earnest, bespectacled, a man who lived life largely in the mind.

Morse and other scientists were identifying

IF THE NEXT PANDEMIC WAS GOING TO BE INFLUENZA, THAT DIDN'T SEEM ESPECIALLY SHATTERING. *THE FLU? PEOPLE GET THAT EVERY YEAR. WE HAVE A VACCINE FOR THAT.*

conditions—climate change, massive urbanization, the proximity of humans to farm or forest animals that were viral reservoirs—that could unleash microbes never before seen in humans and therefore unusually lethal. They were warning that, thanks to an increasingly global economy, the ease of international air travel, and the movement of refugees due to famines and wars, these killer pathogens could easily spread around the world. Sound familiar?

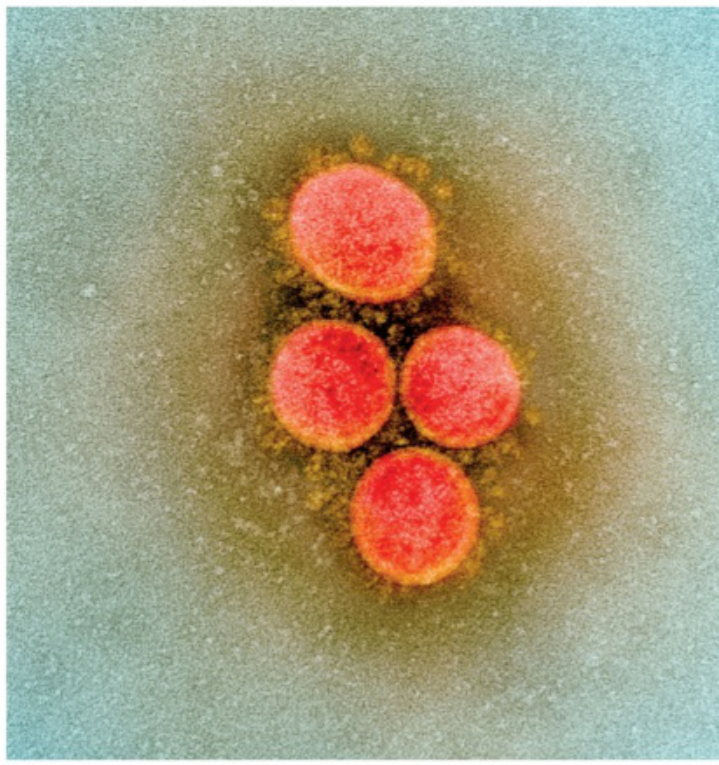
"The single biggest threat to man's continued dominance on the planet is the virus." I used that searing quote from Joshua Lederberg, a molecular biologist who won a Nobel Prize for his work on bacteria, in my book's introduction. Back then I thought Lederberg might have been a bit melodramatic. Now his quote strikes me as terrifyingly prescient.

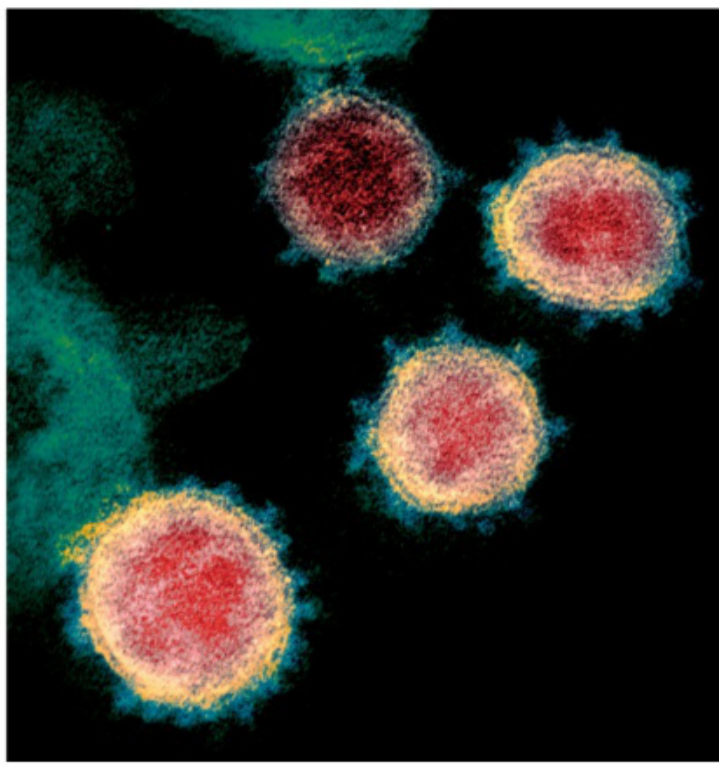
WHEN THE U.S. DEATH TOLL from COVID-19 had not quite reached a thousand and New Yorkers like me were three days into our governor's stay-at-home order, I phoned Morse to see how he was holding up. He teaches epidemiology at Columbia University Mailman School of Public Health and is now in the age range of those most vulnerable to the worst ravages of the coronavirus. (I am too.) He and his wife were self-quarantining in their Manhattan apartment, just a few miles from mine.

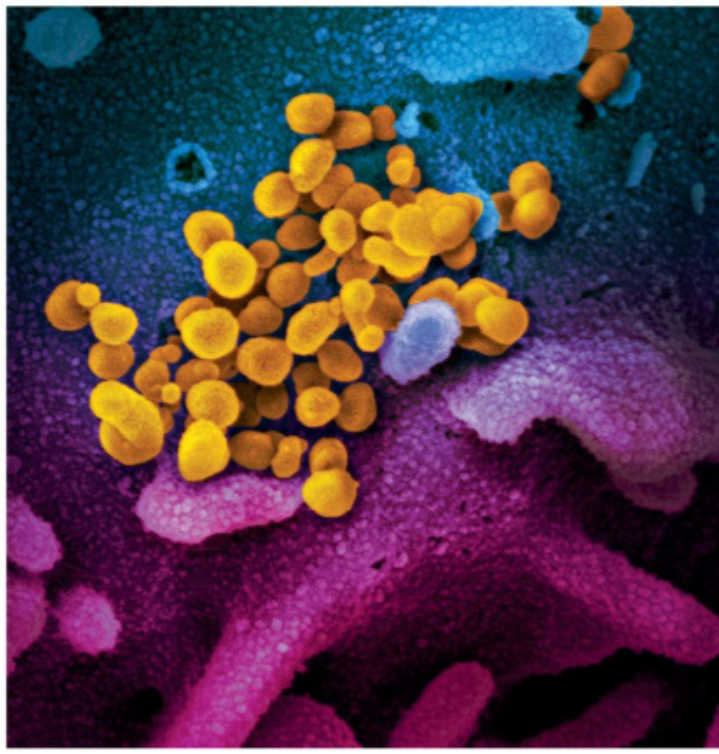
"I'm discouraged, yes, to find we're not better prepared after all this, and we're still deep in denial," Morse said. He went straight to a favorite quote, from management guru Peter Drucker, who once was asked, "What is the worst mistake you could make?" His answer, according to Morse: "To be prematurely right."

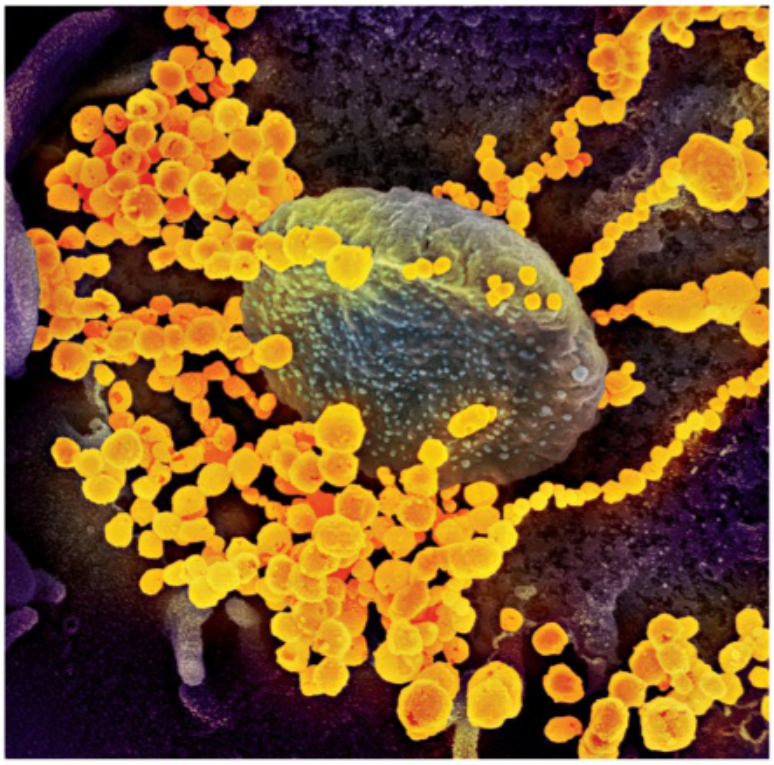
Morse and I weren't right, prematurely or otherwise. Nobody was. When I was asked on my book tour what the next pandemic would be, I said most of my expert sources believed it would be influenza. "I never liked lists," Morse told me during our call; he said he always knew the next plague could come from anywhere. But in the early 1990s he and his colleagues tended to focus on influenza, so I did too. Maybe that was a mistake; if the next pandemic was going to be influenza, that didn't strike most as especially shattering. *The flu? People get that every year. We have a vaccine for that.*

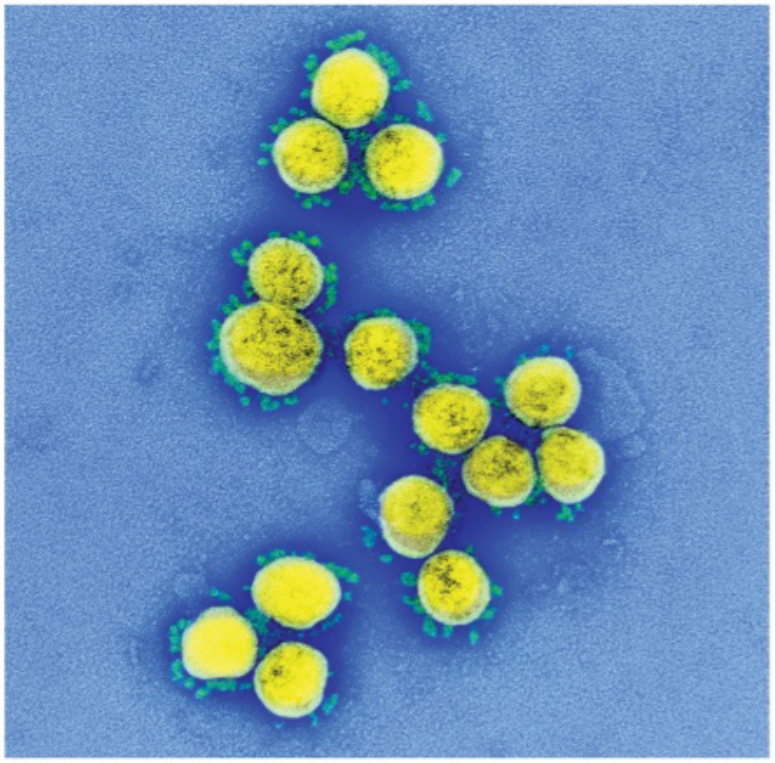
So maybe the warnings were too easy to dismiss as "just the flu" or as the catastrophic thinking of one overwrought writer. But other journalists were

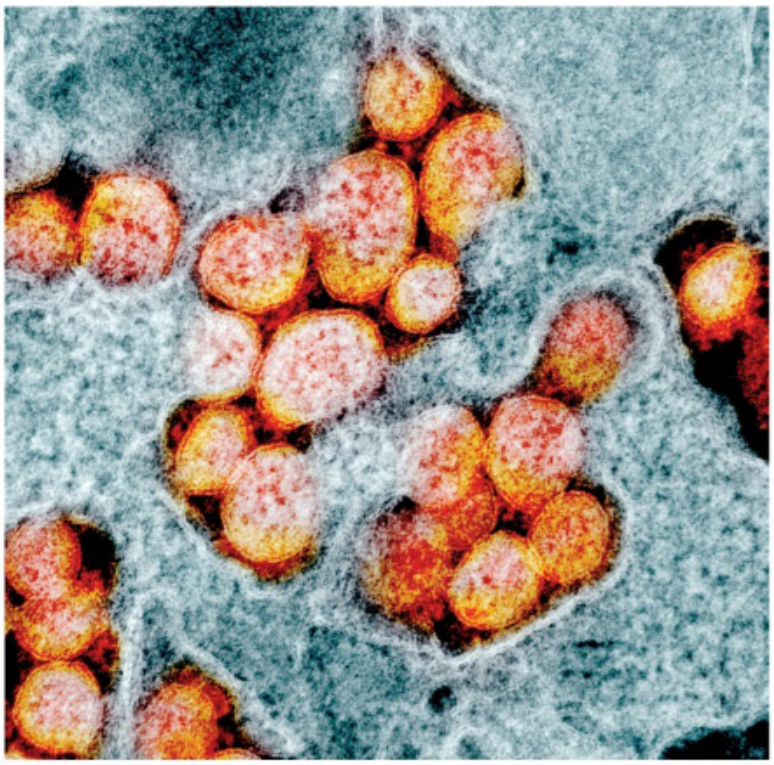


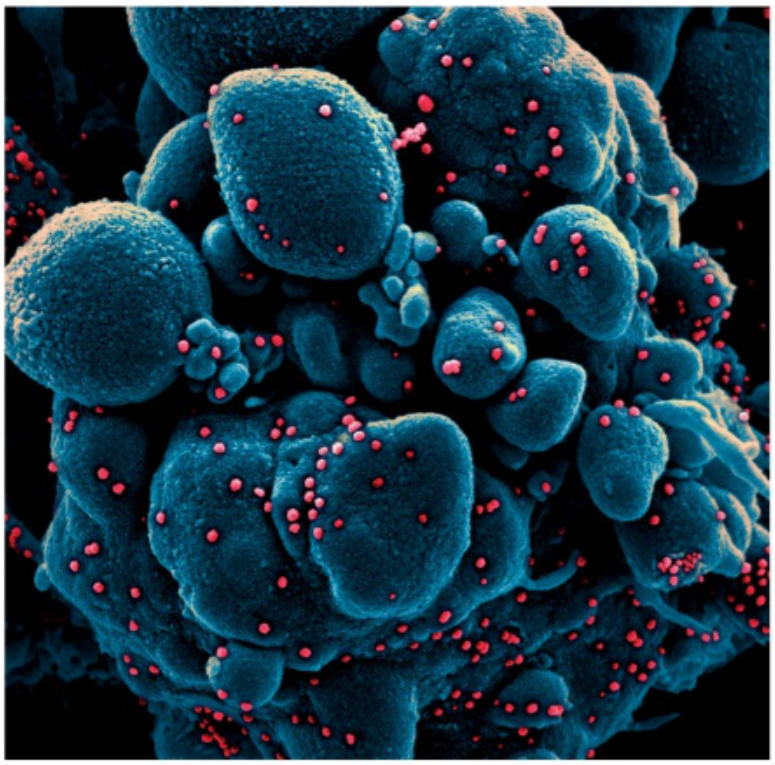


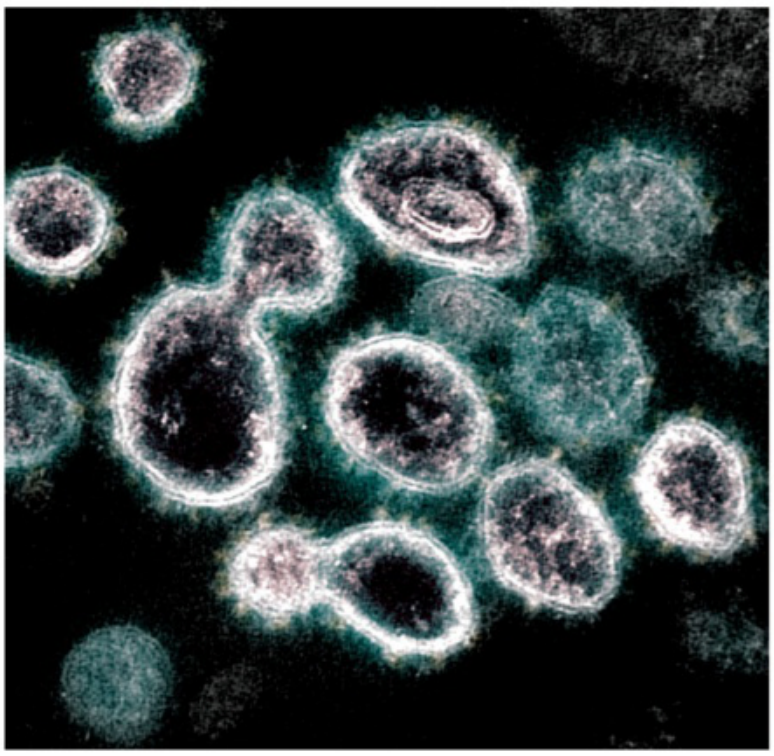


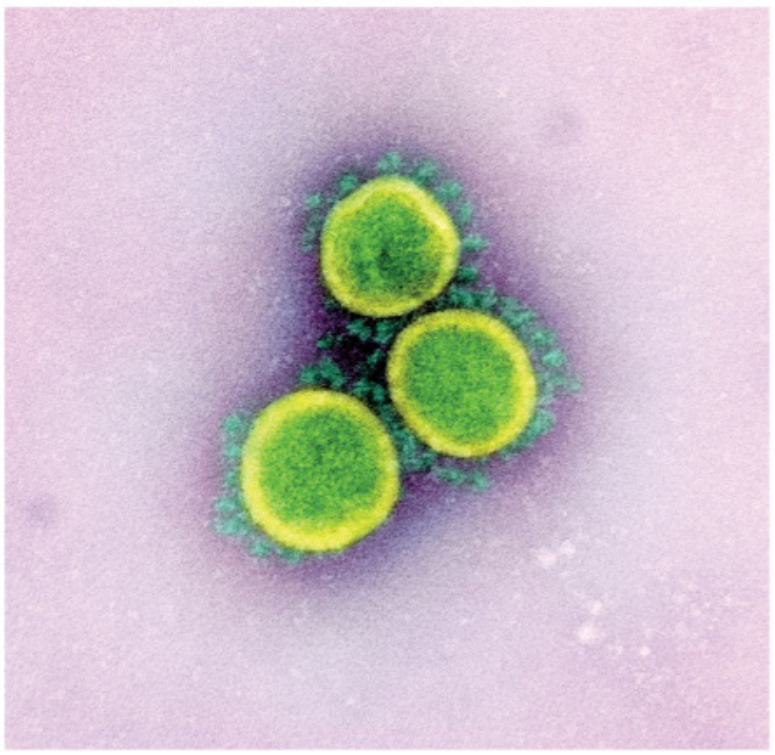












MICROSCOPIC, COLOR-ENHANCED IMAGES OF PARTICLES OF THE NOVEL CORONAVIRUS, SARS-COV-2. PHOTOS: NIAID

writing similar books, and some of them were huge best sellers, like *The Hot Zone,* by Richard Preston, and *The Coming Plague,* by Laurie Garrett, which came out the year after mine. (Other more recent books include *Spillover,* David Quammen's follow-up to a story on zoonotic diseases that he wrote for *National Geographic* in 2007.) All of us described the same dire scenarios, the same war games, the same cries of being woefully unprepared. Why wasn't any of that enough?

The late Edwin Kilbourne might have had something to say about that. A leading influenza vaccine researcher, Kilbourne was gaunt and goateed; in my book I described him as a cross between Pete Seeger and Jonas Salk. At a conference in the mid-1980s, Kilbourne invented a scenario about a fictitious nightmare virus with qualities that would make it the most contagious, most lethal, and most difficult to control. He called it "maximally malignant (monster) virus," or MMMV. As Kilbourne described it, among MMMV's other nefarious attributes, it would be transmitted through the air like influenza, would be environmentally stable like polio, and would insert its own genes directly into the host's nucleus like HIV.

THE NOVEL CORONAVIRUS isn't Kilbourne's ghoulish MMMV, but it does have a lot of its scariest properties. It's transmitted through the air, replicates in the lower respiratory tract, and is thought to last for days on countertops. In addition, people can have mild or asymptomatic cases, meaning that even though they are infectious, they often feel healthy enough to walk around, go to work, and cough on us. In that way it's even worse than influenza and even harder to contain.

But just as Morse said he's never liked "Most Likely to Endanger Us" lists, Kilbourne told me 30 years ago that he'd conjured MMMV for illustrative rather than predictive purposes. "With viruses, in which only a few changes can make a huge difference in the way the microbes behave, trying to predict the paths of evolution and emergence can be a treacherous affair," he warned.

In countries like mine, we might have become inured to the threat of a global pandemic because we saw so many "This Is the Big One" threats flaming out, confined to regions that felt comfortably remote. Except for AIDS, raging epidemics have tended not to go global: SARS in 2003 pretty much stayed in Asia, MERS in 2012 didn't really leave the Middle East, Ebola in 2014 was mostly a West African scourge. As we kept watching ourselves dodge a bullet, it was easy to attribute susceptibility in other countries to behaviors that didn't exist in ours. Most of us didn't ride camels, didn't eat monkeys, didn't handle live bats or civet cats in the marketplace.

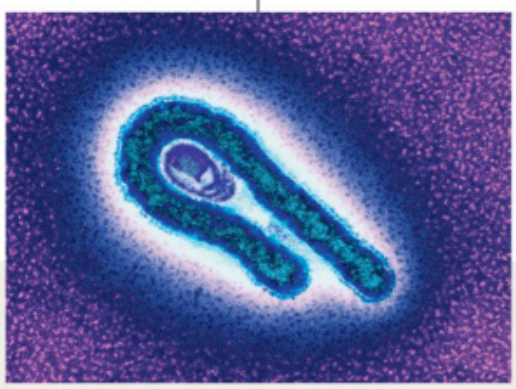
This "othering" of the threat has, in many ways, been our undoing all along. In rereading my book recently, I found a sentence that highlights the persistence of this shameful attitude. "Ask a field virologist what constitutes an epidemic worth looking into," I wrote, "and he'll answer with characteristic cynicism, 'The death of one white person.'"

I've turned my file drawers inside out looking for an old notebook that might contain the name of one such "field virologist," to no avail. But even without that crucial confirmation, I believe in the essential point of that haunting sentence. We've been "othering" away the safety of our species for decades. We're doing it still, fostering an official and personal complacency that ultimately brought humanity to its knees.

What's it been like to watch the coronavirus pandemic unfold nearly three decades after I wrote that a pandemic would unfold in pretty much this way? It's induced a strange vertigo, to be honest. It's also sparked an unfamiliar kind of solipsism, enough to make me wonder: If I had made the case for surveillance and preparation more forcefully back then—that is, if I had written a better book—would we be here now?

Still, there's something enlightening about reading the book's stories about the epidemics from the last century, when new viruses kept emerging, raging through a population, and eventually dying out. But never since the 1918-19 influenza pandemic has any been on this scale, and never with this ferocious mixture of transmissibility and lethality. We almost learned the right lessons in the 1990s, and then we ignored them; maybe this time, with prediction having become reality, the lessons will stick. ▯

Robin Marantz Henig is a journalist based in New York City and the author of nine books. She wrote about the emerging field of microbiome science in the January 2020 *National Geographic*.



SARS in 2003 pretty much stayed in Asia, MERS in 2012 didn't really leave the Middle East, Ebola (virus shown above) in 2014 was mostly a West African scourge. As we kept watching ourselves dodge a bullet, it was easy to attribute susceptibility in other countries to behaviors that didn't exist in ours.

PHOTO: PUBLIC HEALTH ENGLAND CENTRE FOR INFECTIONS/SCIENCE SOURCE

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AN ENDANGERED SNOW LEOPARD
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CORONAVIRUS

A SPECIAL REPORT FROM NATIONAL GEOGRAPHIC

JULY 2020

VOL. 238 NO. 1

We Are Not Made for This New Normal

IN PERILOUS TIMES, OUR DEEPEST HUMAN IMPULSE IS TO DRAW CLOSE TO EACH OTHER—THE VERY THING WE'VE BEEN TOLD NOT TO DO.

BY **CYNTHIA GORNEY**

THE NOMENCLATURE WAS so strange at first, and then it was everywhere: in our stories, our questions, our arguments, our dreams. In California, where I live, I wake with a racing heart one morning because in the nightmare I was trying to buy cloth, for a mask, but the other shoppers wouldn't *distance.* How do they say it where you are? I type online to friends in other places, and the responses pile on. *Distanciamento social,* Brazil. *Distanciation sociale,* France. *To meters avstand,* Norway—two meters distance.

From Mexico City comes a picture of the new cartoon superhero, Susana Distancia, grinning from a sort of isolation bubble inside of which she holds both arms straight out to the sides, marking the no-approach zone. A Delhi friend passes on a comic's line about wanting to meet this famous new guy, Soshal Distan Singh. A friend in Boston insists the phrasing has been wrong from the start, that what the coronavirus began forcing upon the world isn't "social" distancing

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Elizabeth and Jeff Yoches celebrate their daughter Sidney's first birthday in Stuyvesant, New York, as family and friends remotely join the party in a video conference.

at all. Anybody fortunate enough to have access to a screen and an internet connection has rushed toward others, wildly, inventively, using live chat and video conferencing to talk, plan, teach, cook, drink, work, dance, sing, weep, exercise, pray, listen, mourn. This distancing is physical, my Boston friend observes. We can connect. We are connecting. We just can't…touch.

We can't throw ourselves into shoulder-to-shoulder rescue work with strangers, the way we would if we were digging someone out of earthquake rubble. We can't funnel into houses of worship or yell together at ballparks.

My local public health instructions, as I write this with summer still more than two months away, probably sound like yours: I must not rest my head on my daughter-in-law's shoulder, rumple my godchildren's hair, or put a hand on my neighbor's arm as we tell each other we'll get through this. Flatten the curve. *To meters avstand.* Maybe two meters isn't enough, it turns out; look up "airborne coronavirus." Or, better yet, don't, because you'll find yourself reading arguments about whether invisible little virus clouds left lurking by six-feet-away heavy breathers could conceivably find their way up our noses. Maybe we should stay 20 feet from other people. Maybe we shouldn't walk out our front doors at all.

FOR HOW LONG? Not knowing, trying to get to sleep every night still not knowing, is one more hammer to the heart. By the time you read this, things will be better where you are, or worse where you are, or zigzagging from worse toward better as long as you sit at least three bar stools away from the next person and figure out how to sip under your mask. Do you love someone whose daily life requires exposure danger? A bus driver, a nurse, a police officer, a home

PHOTO: THOMAS DWORZAK, MAGNUM PHOTOS

BY THE TIME YOU READ THIS, THINGS WILL BE BETTER WHERE YOU ARE, OR WORSE, OR ZIGZAGGING FROM WORSE TOWARD BETTER AS LONG AS YOU SIT THREE BAR STOOLS AWAY FROM THE NEXT PERSON.

health aide, a grocery clerk, a production line worker at a meatpacking plant? Will looking back on 2020 remind you of the last time you could breach the distance barrier without taking a COVID-19 test first?

My daughter is an ambulance-driving paramedic. One city over from mine, that's all, but for us she's a voice on the phone, a face on the screen, until somebody can promise that sharing a kitchen table won't inadvertently set off a new chain of transmission. Our deepest human impulse for the giving and receiving of comfort, especially in crisis—to move closer, to join hands, to feel the literal nearness of others—is the one we cannot indulge.

I listen every morning for the boys across the street. Their mother is Australian, and the school-gone-online routine starts with driveway cricket, one parent pitching, the other jiggling the baby sister. They shout and whoop, the ball smacks off the cricket bat, and somehow it's like the sound of those Italians singing in unison off their balconies, and the people in great cities opening their windows for evening salutes to frontline workers, and the balloon-covered Happy Birthday Kevin! car that honked and blasted music through my neighborhood this week. Halfway out the sunroof and waving like the star of a parade float, his legs pinioned by adults within, Kevin—I'm going to go ahead and assume that was Kevin—had block after block of Oakland residents wishing him a happy birthday and merrily waving back.

"LET US NOT let this virus infect our souls," I heard a local pastor implore his congregation last month. He was getting the hang of preaching by Zoom, the amens floating up the chat window on one side of the screen. A soprano sang a hymn at her living room piano, and it was possible for a while to imagine all this improvisation as terrified humans fumbling for grace and, at odd moments—driveway cricket, a mask-sewing brigade, a How are you? that means something new—finding it.

My husband is a labor lawyer, his days consumed with pandemic-collapsed businesses and workers losing their paychecks. During the outdoor walks we are still permitted to take, we keep reminding each other to notice spring poppies as we distance-veer back and forth, alert to the sound of the phones in our pockets. His sister might be calling, or my brothers, our son, our cousins, our oldest friends. Even on duty, the paramedic daughter checks in occasionally, from the ambulance, between hospital runs.

The mission is reassurance. We all understand that. She hits the FaceTime prompt, if the signal is good enough. During one of the calls, she smiles at us from the little screen and reminds us how we used to assume she would one day take a temporary posting someplace far away and tough, a war zone or a desert refugee camp.

"All we have to do is pretend that's where I am," she says. "And look how lucky we are. With these technological devices, we can see each other from opposite sides of the world." So we have that, for now, for as long as it takes. We will cherish it. We will make it be enough. □

Cynthia Gorney is a *National Geographic* contributing writer. She previously has reported on vaccine research and distribution in the developing world, and on guest workers living far from their families in order to send money home.

CORONAVIRUS

A SPECIAL REPORT

WHEN THE VIRUS CAME TO KENYA

IN BUSY SETTLEMENTS, PANDEMIC FEARS AND HOMEMADE FACE MASKS

PHOTOGRAPHS BY **NICHOLE SOBECKI**

A mural reads “Let’s fight corona together!” on a stall in Nairobi’s impoverished Kibera neighborhood. In communities such as this, where hundreds of thousands of people live in close quarters and depend on each other for daily necessities, self-isolation and social distancing are difficult to put into practice.

In hopes of slowing the spread of COVID-19, emergency services workers fumigate key public and market areas in Nairobi's central business district. Lacking sufficient tests and medical equipment,

the national government imposed a curfew to limit activity—but that led to heated confrontations between police and those suspected of violating the government orders.

Like many people worldwide, Kenyan fashion designer David Avido, 24, is seeking creative solutions to keep people in their communities safe. In Kibera, where he grew up, Avido distributes free face masks

that he makes from bright textiles, as a preventive measure against the coronavirus. In this and other packed settlements, residents often cannot find—or pay for—protective masks and cleaning supplies.

THE BACKSTORY

STAYING SAFE FROM COVID-19 CAN BE AN UNAFFORDABLE LUXURY IN THE CROWDED SETTLEMENTS OF NAIROBI.

FOR MOST PEOPLE in Kenya, life finds a way to go on despite COVID-19. But defending against the deadly virus is especially challenging in one of the world's most unequal countries: Almost 37 percent of the 53 million people there live on $1.90 or less a day. And self-quarantining can go only so far in a place where many rely on informal markets for food, medicine, and employment.

Since mid-March, when the coronavirus came to Kenya, I've watched the virus spread through Nairobi, where I've lived for eight years. I've followed paramedics and visited the homes of people scared of the virus and its economic havoc. A month after its first case, Kenya had confirmed fewer than 200 cases, and just eight deaths. "But even these small numbers are more than we can handle," one paramedic told me. "When the numbers really start to rise, people will be dying in the streets."

Last year I was in the Democratic Republic of the Congo as Ebola ravaged the country. That epidemic taught me that meeting each other's basic needs depends on our shared abilities to adapt in a time of uncertainty.

David Avido understands that. On the previous page you'll see Avido, a fashion designer, in Kibera, an impoverished part of Nairobi. To help his country fight COVID-19, he switched from making clothes to sewing colorful masks that he hands out for free. "I believe that all of us deserve the same chance to protect ourselves," he told me. "We're all responsible for one another." —NICHOLE SOBECKI

In informal economies, vendors like this bird merchant often can't afford to stay home from work.

NGM MAPS

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Safe, naturally edible treats made to satisfy your dog's instinctual love of chewing.

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Hands Free of Virus

WILL THE WORLD'S POOR FINALLY GET THE CLEAN WATER THEY NEED TO WASH THEIR HANDS—AND DRINK?

BY **NILANJANA BHOWMICK**

"YOU HAVE COME FROM MUMBAI to teach us about handwashing?"

The villagers couldn't stop laughing at Yusuf Kabir. He works at UNICEF's Mumbai office, in a division with an apt acronym—WASH, for water, sanitation, and hygiene—and he was on a tour of the Latur district, some 250 miles east of Mumbai, to advocate hand hygiene as a safeguard of health. In Latur, as elsewhere in the state of Maharashtra, Kabir was learning that handwashing just wasn't a priority for many villagers. "They couldn't see any tangible impact," he recalls.

That was long before the COVID-19 pandemic.

On March 24, the same day Prime Minister Narendra Modi ordered India's more than 1.3 billion citizens to stay inside their homes for at least three weeks—a period he later extended—researchers at the University of Birmingham in the United Kingdom released a study documenting a strong correlation between the size of a country's COVID-19 outbreak and the weakness of its handwashing culture. China, where the pandemic began in late 2019, had the weakest result: Seventy-seven percent of those surveyed reported that they didn't automatically wash their hands after using the toilet. India did better—but 40 percent of Indians still said they didn't wash their hands, with or without soap, at that crucial moment.

That survey too was done before COVID-19.

A woman bathes near Bhubaneshwar, a city in the eastern Indian state of Odisha. A majority of urban households in India—and 82 percent of rural ones—lack piped water.

This year, Indians have been getting the message as never before: Frequent handwashing with soap prevents disease. They've been getting it from their national and state governments. They've been getting it on social media, from Bollywood stars and from cricket champions and, most entertainingly, from a squad of uniformed, face mask–wearing policemen in the southern state of Kerala, who danced in synchronous formation to a popular tune while demonstrating proper handwashing technique.

As the coronavirus has torn through the world, not sparing the rich and the powerful, India's rural poor have felt their own acute vulnerability, Kabir says, and that has made them more open to the message. Soap, he says, is now one of the top items sold in village shops, right behind rice and wheat flour.

Even before COVID-19, Kabir had a long list of arguments for soap buying and handwashing. Worldwide in 2018, pneumonia killed more than 800,000 children under the age of five, including 127,000 in India. Diarrhea, usually caused by rotavirus infection, killed more than 500,000 children, including more than 100,000 Indians. Handwashing with soap is a first defense against both diseases, as it is against cholera, dysentery, hepatitis A, and typhoid. It can cut the risk of diarrhea by 40 percent, UNICEF says.

The great hope of WASH activists like Kabir is that the fear of COVID-19 will inspire a surge in

PHOTO: ANDREA BRUCE

handwashing that, in a post-pandemic world, will lead to a lasting reduction in the disease burden of many developing countries.

This is "probably the only silver lining of the disease," says VK Madhavan, CEO of WaterAid India. "The change and awareness about it now, as compared to a few weeks back, is phenomenal."

But there's a daunting obstacle to realizing that hopeful vision: In places like India, there's just not enough clean water.

IF YOU ADD UP all the situations in which international authorities such as UNICEF recommend washing hands during this pandemic—after visiting a public space or touching a surface outside the home, after coughing, sneezing, or blowing your nose, and of course after using the toilet or taking out garbage and before and after eating—it easily amounts to at least 10 times a day.

That's a lot of handwashing. A single 20-second wash plus wetting and rinsing uses at least two liters of water, more than half a gallon. A family of four washing 10 times a day each would use 80 liters just for handwashing. In the United States, where the average person consumes up to 100 gallons daily (around 379 liters), that's no big deal. In much of India and other parts of the developing world, it's an unimaginable luxury.

Last year, after Chennai, India's sixth largest city, ran out of water during a prolonged drought, NITI Aayog, an Indian governmental think tank, released a report on the country's ongoing water crisis. It found that nearly 60 percent of India's urban households don't have piped running water. In the countryside, the figure rises to 82 percent, or 146 million rural homes without an adequate water supply.

Here's just one example of what that life looks like.

A teacher demonstrates proper handwashing technique for young students at a school in Gori Kothapally village, in India's Andhra Pradesh state.

PEOPLE IN KAITHI FACED A DISCONCERTING CHOICE: THEY COULD WASH THEIR HANDS OR KEEP THEIR SOCIAL DISTANCE, BUT IT WAS HARD TO DO BOTH.

In the village of Kaithi, in the Bundelkhand region in north-central India, there is one shared tap for every five households. Bundelkhand has suffered 13 droughts in the past two decades. Water shortage is a way of life here.

This spring, as COVID-19 began spreading, people in Kaithi, as in so many other Indian villages, faced a disconcerting choice: They could wash their hands or they could keep their social distance, but it was hard to practice both methods of warding off the disease at the same time. "We are not allowing too many people to crowd around the taps and trying to wash our hands as much as possible," Kaithi resident Mangal Singh told me by phone after the lockdown began.

Like many Indian villages, Kaithi has a colony at one end inhabited only by lower-caste Dalits. There, some 400 people share a single tap. And many people in the region don't have access to any nearby water source, says Kesar Singh, convener of the Bundelkhand Water Forum, a local nonprofit. Women in such villages often travel more than a mile and stand in a long line to fetch water.

"To expect that people in this poverty-stricken, water-deficient region will prioritize handwashing over daily living is nothing short of a cruel joke," Singh says.

Worldwide, some three billion people—40 percent of the global population—lack basic facilities to wash their hands with soap and water at home, according to a report released last year by the World Health Organization and UNICEF. Most are in either South Asia or sub-Saharan Africa.

"It's not that people do not like the idea of handwashing," says Kenya-based indigenous rights activist Ikal Ang'elei, echoing what Singh told me. "It's like this: Do you make your child wash his hands after he comes back from school, or do you save the water for cooking?"

In India, the Modi government announced plans last year to provide every household with 55 liters of water a day by 2024. The goal is hugely ambitious—and still far from equal to both the need and the opportunity that will exist in a post-COVID-19 world.

"The awareness about sanitation and handwashing will be at its peak now," says Kelly Ann Naylor, global WASH chief at UNICEF. "But it will have to be taken forward by governments." ☐

Nilanjana Bhowmick is a writer in Delhi, India.

PHOTO: SANJIT DAS/PANOS PICTURES/REDUX

THE

ROOF OF THE WORLD ISSUE

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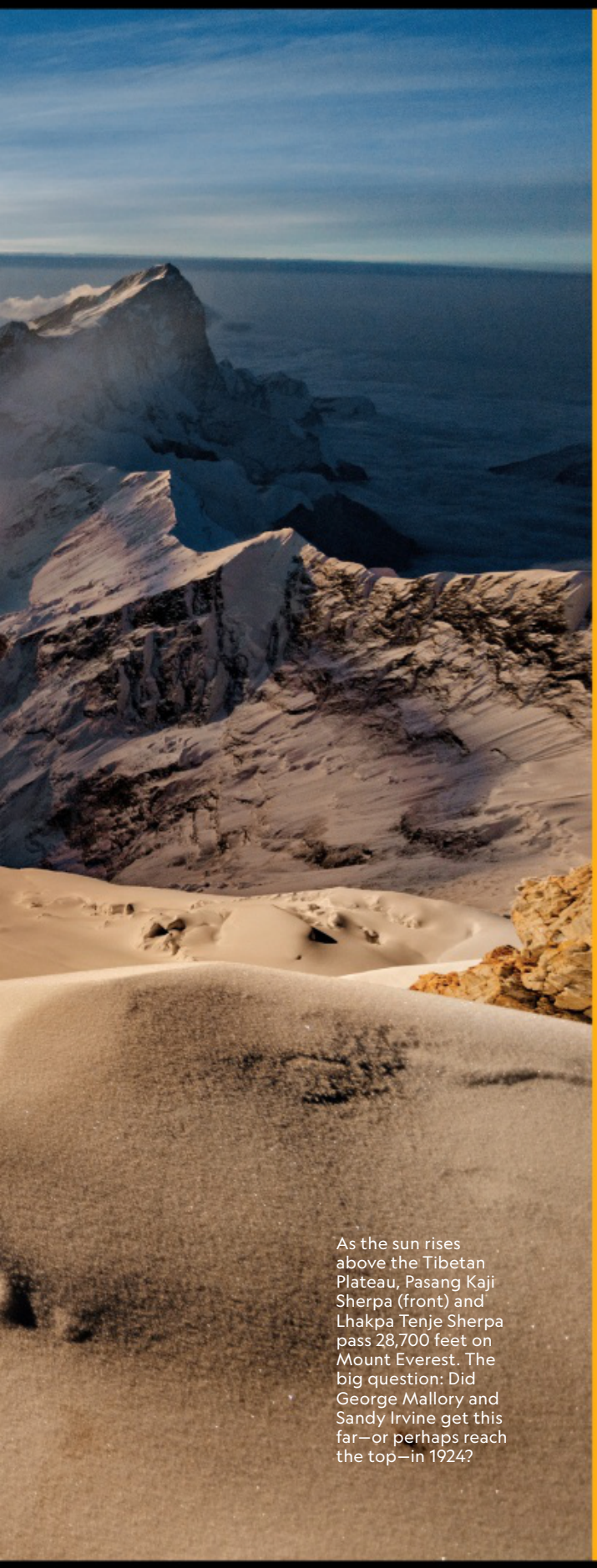

As the sun rises above the Tibetan Plateau, Pasang Kaji Sherpa (front) and Lhakpa Tenje Sherpa pass 28,700 feet on Mount Everest. The big question: Did George Mallory and Sandy Irvine get this far—or perhaps reach the top—in 1924?

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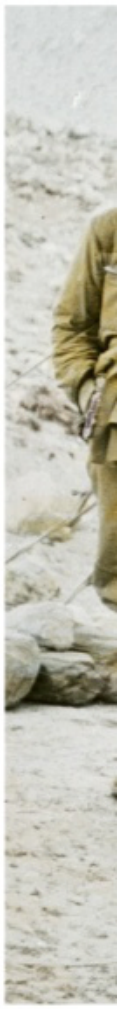
THE GREAT MYSTERY OF EVEREST

BY **MARK SYNNOTT** PHOTOGRAPHS BY **RENAN OZTURK**

Snow dusts the rocky Miracle Highway on the East Rongbuk Glacier as a group of climbers (above) makes the 12-mile trek between Base Camp and Advanced Base Camp past bladelike ice fins.

Nearly a century ago, Sandy Irvine and his climbing partner, George Mallory, vanished on a high ridge of Everest. Did they make it to the top, 29 years before Edmund Hillary and Tenzing Norgay were celebrated as the first to scale the world's highest peak? The author and his team retraced Irvine's steps to try to find his body—and the camera that could rewrite the story of the mountain.

NATIONAL GEOGRAPHIC



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JOHN NOEL, MOU

IT," he said. "You're too tired. It's not

cGuinness, our guide and expedition
ked hard at me with sunken, blood-
He had slipped off his oxygen mask
ed his sunglasses. Several days of gray
vered his chin. His skin had a sallow,
pallor.
sitting on a pile of rocks at 27,700 feet
theast Ridge of Mount Everest—the
de, away from the crowd in Nepal. A
ndred feet below us was the GPS way-
could solve one of the greatest myster-
ntaineering. New research indicated
dary British explorer Andrew "Sandy"
y have tumbled and come to rest at
Was his body still there?

NT EVEREST EXPEDITION 1924. ROYAL GEOGRAPHICAL SOCIETY

In this hand-tinted image, a smiling Irvine (at far left) stands next to Mallory, who rests his boot on E.O. Shebbeare, a transport officer. With tough, experienced climbers, the 1924 team made the third British attempt in four years to scale Mount Everest.

LOST ON EVEREST
Follow a team of veteran mountaineers as they search for Sandy Irvine and his camera. This one-hour special airs June 30 at 9/8c on National Geographic.

Almost a century ago, while descending this ridge, Irvine and his climbing partner, George Mallory, vanished. Since then the world has wondered whether one or both of them could have made it to the top that day, 29 years before Edmund Hillary and Tenzing Norgay were recognized as the first to stand on Everest's summit. Irvine was thought to have been carrying a Vest Pocket Kodak camera. If that camera could be found, and it held snapshots of the summit, it would rewrite the history of the world's tallest peak.

I scanned the terrain around me. A series of short, steep cliffs was sandwiched between snow- and rubble-covered ledges in an area of light-colored rock known as the Yellow Band. Fourteen thousand feet below, the arid plain of the Tibetan Plateau shimmered like a mirage.

I had barely slept in the past 48 hours and was weak and nauseated from the extreme altitude. Since setting off from Advanced Base Camp at 21,000 feet three days earlier, I had been able to choke down only a few bites of freeze-dried curry, a handful of cashews, and a single bite of a candy bar on Everest's summit—which I later threw up. I was so tired, my oxygen-starved brain begged me to lie back and close my eyes. But some vestige of clarity and reason understood that if I did, I might never wake up.

A few small rocks clattered from above. I looked up to see photographer Renan Ozturk working his way down the ridge toward us. His arm was wrapped around the skinny purple fixed line that was our umbilical cord to the summit, where we had stood several hours earlier. He skidded to a stop and plopped down beside me.

I turned to face him. "What do you think?"

He didn't reply right away, his chest heaving in and out. Finally he caught his breath, and I heard his muffled voice through his oxygen mask. "You should go for it."

I nodded, unclipped from the line, and took my first tentative steps down the sloping ledge of rocks. The moment I left the rope, Lhakpa Sherpa yelled, "No, no, no!"

I waved at him. "I just need to check something out. I'm not going far."

But he implored me to stop. "Very dangerous, very dangerous!"

As a veteran climber

Bound for the North Col, climbers typically spend a night or two at 23,000 feet to acclimate themselves before a later try at the summit. Although less crowded than Everest's Nepali side, the Chinese side can still get dangerously busy.

MATTHEW IRVING

and guide who had summited Everest multiple times, he knew that one bad slip on the loose scree and I could plummet 7,000 feet to the Rongbuk Glacier. Part of me agreed with him and wanted to call it off. After decades of mountaineering all over the world, including as a professional guide, I had promised myself never to cross any line where the objective risk was too high. After all, I had a family back home that I dearly loved.

But I ignored McGuinness, Lhakpa, and my own promise now. The mystery of Irvine's disappearance was too strong.

> I had long known the theory that Mallory and Irvine might have been the first to scale Everest.

But I had caught the fever to find Irvine only two years before, after attending a lecture by my friend Thom Pollard, an Everest veteran who lives a few miles from my home in the White Mountains of northern New Hampshire. He called me a few days later.

"You don't think you could actually find him, do you?" I asked.

He chuckled. "What if I had a critical piece of information that no one else has?"

"Like what?" I shot back.

He paused for a few seconds. "Like the exact location of the body."

Pollard had been a cameraman on the 1999 Mallory and Irvine Research Expedition, during which American alpinist Conrad Anker had found the remains of George Mallory on this part of Everest's north face, where only a few climbers have ventured. The body had been embedded facedown in the gravel as if it had been laid into a slab of wet concrete.

Mallory's entire back was exposed, the preserved skin so clean and white it looked like a marble statue. A severed cord tied around his waist had left rope marks on the torso, a clue that at some point Mallory likely had taken a hard, swinging fall. What struck me most was the way the left leg was crossed over the right, which had broken above the boot top, as if Mallory was protecting the injured limb. Whatever had happened, it seemed clear that Mallory had been alive, at least briefly, when he'd arrived at his final resting-place.

After the dinner rush, the cooking crew relaxes with visitors. Nepali cook Bire Tamang (back right) and his Tibetan assistant Chhumbi (right) prepared hearty meals of rice and lentils, soup, and noodles for 30 to 40 people a day, including Da Gelje (Dawa) Sherpa (back left), who led the support team, and Pasang Gomba Sherpa, a private guide.

Anker and his fellow searchers initially assumed the body was Sandy Irvine's because it was found almost directly below the spot where Irvine's ice ax had been discovered on the ridge nearly a decade after he and Mallory disappeared. Had Mallory been tied to Irvine at the time of the fall? And if so, how did the rope get cut, and why was Irvine not found nearby?

Other details raised more questions. Mallory's green-tinted goggles were found in his pocket. Did that mean he was descending at night, when he wouldn't need them? His wristwatch had stopped between one and two, but was that a.m. or p.m.? Mallory had made it known that if he made

it to the summit, he would leave his wife's picture on top. There was no picture of her on his body.

There was also no trace of the camera, which has led many Everest historians to conclude Irvine must have been carrying it. This makes sense considering he was the better photographer and would have known the British public would want photos of their Galahad—as his admirers had nicknamed Mallory—rather than his lesser known partner.

The last person to see the pair was their teammate Noel Odell, who stopped at around 26,000 feet on June 8, 1924, to turn his gaze toward the summit. A thick, cottony veil had obscured the upper reaches of the mountain, but at 12:50 p.m. the swirling clouds lifted momentarily, revealing Mallory and Irvine "moving expeditiously" upward about 800 feet from the summit, Odell reported.

"My eyes became fixed on one tiny black spot silhouetted on a small snow crest," Odell wrote in his dispatch of June 14. "The first then

I HAD PROMISED MYSELF NEVER TO CROSS ANY LINE WHERE THE OBJECTIVE RISK WAS TOO HIGH. **BUT I IGNORED MY OWN PROMISE NOW.**

The top of the world seems as distant as the Milky Way from Advanced Base Camp, where more than 200 people sprawl across a quarter mile of glacial moraine. The summit is the rightmost peak, barely visible beyond the snowy saddle of the North Col (at right).

The tinkling of bells accompanies yaks hauling propane and other supplies all the way to Advanced Base Camp at 21,000 feet. This is higher than they can go on Everest's Nepali side, where Sherpas carry everything up the Khumbu Icefall.

TOP LEFT

Blasted by hurricane-strength winds at 23,000 feet, Nick Kalisz clings to a broken tent after a harrowing storm the night before. A member of the expedition's film team, he was later evacuated to Kathmandu to be treated for potentially life-threatening pulmonary embolisms.

TOP RIGHT

Pasang Kaji Sherpa follows a fixed line across a rocky stretch not far from Everest's summit. On the day the team reached the top, they were the only climbers on either side of the mountain.

JAMIE MCGUINNESS

BOTTOM LEFT

To make camps more comfortable for clients, Sherpas and other support climbers carry bedding and foam pads up the steep slope to the North Col. Everything from tents and oxygen bottles to stoves, food, and fuel must be carried above Advanced Base Camp. "The fact is, the weight of every enterprise on Everest rides on the backs of Sherpas," said author Mark Synnott.

BOTTOM RIGHT

Photographer Renan Ozturk fist-bumps a climber returning to Advanced Base Camp.

HIGH HOPES

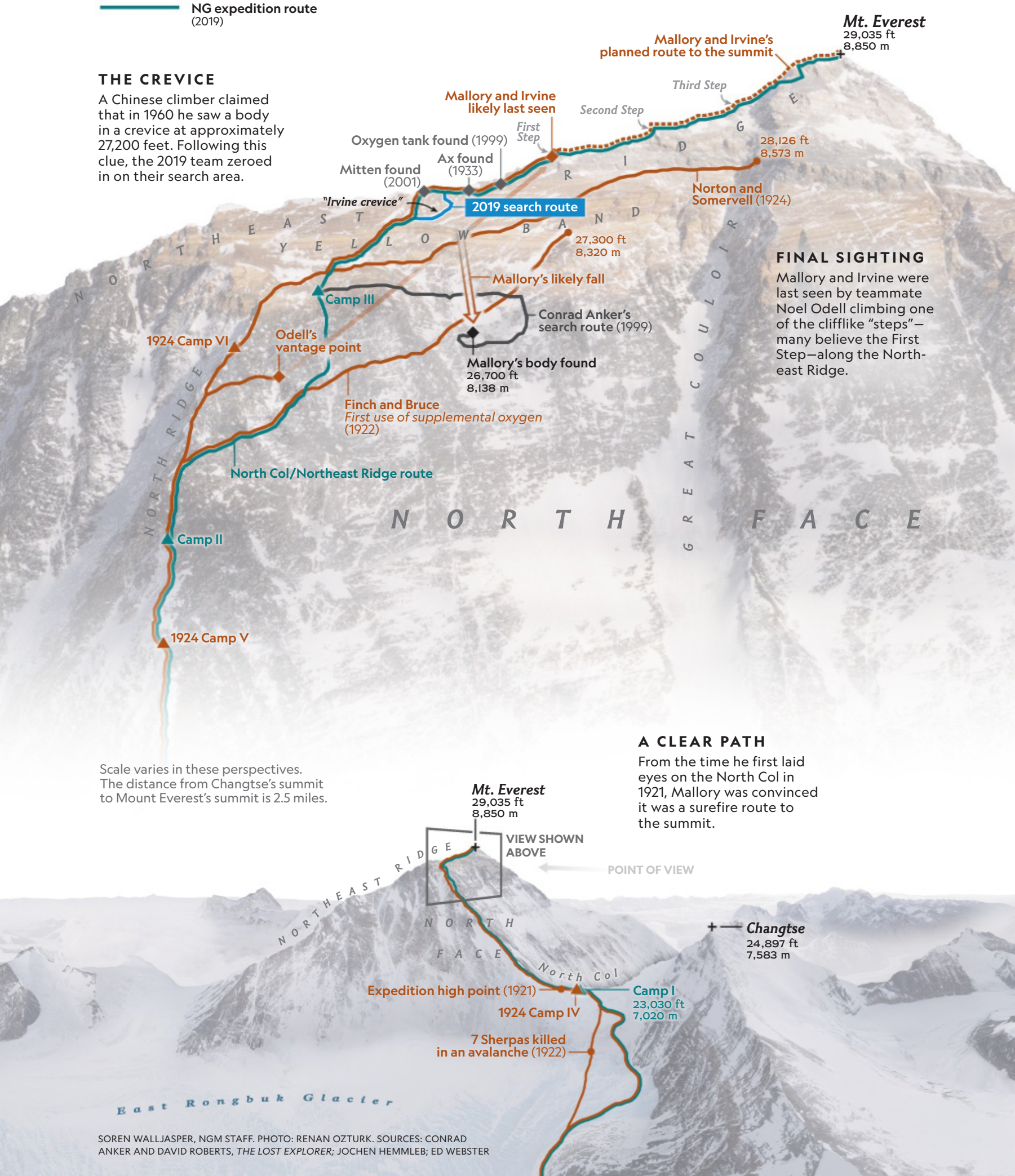
The British launched three expeditions to Mount Everest in the 1920s, hoping to be the first to the summit. On the final push of the 1924 expedition, George Mallory and Sandy Irvine went missing. No one knows whether they reached the top, a feat that, if proved, would rewrite climbing history. A 2019 National Geographic expedition sought answers, but the mystery remains unsolved—for now.

British expedition routes
(1921, 1922, and 1924)

NG expedition route
(2019)

THE CREVICE

A Chinese climber claimed that in 1960 he saw a body in a crevice at approximately 27,200 feet. Following this clue, the 2019 team zeroed in on their search area.



FINAL SIGHTING

Mallory and Irvine were last seen by teammate Noel Odell climbing one of the clifflike "steps"—many believe the First Step—along the Northeast Ridge.

Scale varies in these perspectives. The distance from Changtse's summit to Mount Everest's summit is 2.5 miles.

A CLEAR PATH

From the time he first laid eyes on the North Col in 1921, Mallory was convinced it was a surefire route to the summit.

SOREN WALLJASPER, NGM STAFF. PHOTO: RENAN OZTURK. SOURCES: CONRAD ANKER AND DAVID ROBERTS, *THE LOST EXPLORER;* JOCHEN HEMMLEB; ED WEBSTER

approached the great rock step and shortly emerged at the top; the second did likewise. Then the whole fascinating vision vanished, enveloped in cloud once more."

UNTIL NOW I had resisted the idea of climbing Everest, turned off by stories about the crowding, the greenhorns who had no business being on the mountain, and the outsourcing of risk to the climbing support team, mostly ethnic Sherpas, who carried the weight of everyone's egos on their shoulders and sometimes paid with their lives when Qomolangma—the Tibetan name for the mountain—showed its displeasure with storms, earthquakes, and avalanches.

That was one reason I never understood Pollard's obsession with the peak. But as we continued to talk in the months after his lecture, Mallory and Irvine's story intrigued me more and more. During one of these conversations, Pollard told me about Tom Holzel, a 79-year-old entrepreneur, inventor, writer, and Everest enthusiast who has spent more than four decades trying to solve this mystery.

Back in 1986, Holzel had led the first expedition to search for Mallory and Irvine with Audrey Salkeld, a preeminent Everest historian. But unusually heavy snows that autumn had kept their team from getting high enough on the Chinese side of the mountain. If conditions had been better, they might well have found Mallory's body, which was later discovered within a hundred feet of the spot Holzel had targeted.

His next idea was to use an aerial photo taken during a National Geographic–supported Everest mapping project headed by explorer Bradford Washburn to try to pin down the exact spot on the mountain where a Chinese climber claimed to have spotted Irvine's body. Xu Jing was deputy leader of the Chinese expedition that made the first ascent of Everest's north side in May 1960. According to Xu's account, after bailing from the summit attempt, he was taking a shortcut down through the Yellow Band when he spotted an old dead body inside a crevice at approximately 27,200 feet. At the time of this sighting, the only two people who had died this high on the north face of Everest were Mallory and Irvine. By the time Xu gave his account, in 2001, Mallory's remains had already been found lower on the mountain.

When Pollard and I visited Holzel in December 2018 at his home in Litchfield, Connecticut, he showed us on his eight-foot-wide blowup of the Washburn photo that there was only one route that made sense as Xu's shortcut. Through a process of elimination and a detailed analysis of the terrain features, Holzel had homed in on a single crevice that he believed to be the location of Irvine's body and had determined the precise latitude and longitude for this spot.

I pointed to the red circle on the giant photo. "What are the odds that he's actually here?"

"He can't not be there," Holzel said.

It was a fluke, in many ways, that Irvine had even made it to Everest.

The shy, athletic 21-year-old was still an undergraduate at Oxford's Merton College when the Mount Everest Committee invited him to join the expedition in 1923. Unlike more seasoned members of the British team, Irvine had limited climbing experience, having scaled modest peaks in Spitsbergen, Wales, and the Alps, far from the giants of the Himalaya.

And yet, by the time the group reached the mountain, this youngest member of the team, whom the Mount Everest Committee had called their "superman," had won the respect of his teammates and proved his usefulness by completely redesigning their newfangled oxygen gear. A gifted engineer and tinkerer, he had taken the oxygen sets apart and put them back together, making them lighter, less cumbersome, and less prone to breaking.

A few months before our own expedition in 2019, I traveled to England to visit the Sandy Irvine Archive at Merton. (My grandfather, coincidentally, attended Merton a few years after Irvine.) The archive consists of 25 boxes of papers, photos, and other memorabilia, including Irvine's Everest diary, recovered from the mountain after his disappearance. About eight inches tall by five inches wide, with a black cloth cover, the volume captures Irvine's youthful enthusiasm.

Archivist Julian Reid brought me the book, laying it on a protective foam pad. He paged to the last entry and said, "When I read it, it made the hair on the back of my neck stand up."

Irvine scribbled his last entry on the evening of June 5, when he and Mallory were camped at 23,000 feet on the North Col, a narrow snow saddle connecting the north face of Everest to the subpeak known as Changtse, where they were poised to begin their summit bid the next day. He complained to his diary that his fair skin had been cracked and blistered by the sun. "My face is perfect agony. Have prepared 2 Oxygen apparatus for our start tomorrow morning."

I had the same reaction as Reid's upon reading Irvine's words, along with a profound sense of sadness. When Irvine vanished, he was the same age as my oldest son.

Film crew member Matthew Irving plucks foil from Renan Ozturk's crampon at a high camp filled with trash. Many climbers are so wiped out as they descend, they have no strength left to remove tents, cooking gas, or other gear from high camps.

Before we could conduct our search for Irvine, we had to acclimate to the high elevation and test our secret weapons: a small fleet of drones.

Ozturk, a talented filmmaker, is also a self-professed "drone nerd" and hoped to use these unmanned aerial vehicles to search not only the so-called Irvine crevice but also the entire north face of the mountain.

On May 1, 2019, our team sat around a folding table in the dining tent, perched at 21,000 feet on a stone platform at Advanced Base Camp, on the edge of the East Rongbuk Glacier. It was warm, and the tent was tied open, giving me a perfect view of Everest's northeast face. A plume of snow, like the tail of a white dragon, trailed off the summit for miles.

"That's a Category 4 cyclone," McGuinness said, pointing to a brightly colored swirl in the Bay of Bengal on his laptop. "It could dump a foot of snow on us in the next few days."

Our plan was to fly the drones from the North Col the next day. We were eager to test their capabilities at high altitude. But McGuinness was skeptical. "It might get too windy up there."

He was right. The gusts on the North Col a day and a half later were so strong that Ozturk couldn't even bring the first drone all the way back. He had to land it nearby to retrieve it.

That night we huddled in our tent as the storm grew stronger. We were 2,000 feet higher now than Advanced Base Camp, and I had a racking cough and felt listless and slightly nauseous, as if suffering from a combination of the flu and a bad hangover. As my headache built, so too did the wind, until the tent fabric was flapping violently. Sometime before midnight I heard what sounded like a 747 taking off above our heads. A few seconds later the tent was flattened, and I was held down by the hand of an invisible giant. The gust lasted only a few seconds before the tent rebounded, but I knew more was coming.

Over the next couple of hours the tempest

built, until around 2 a.m., when a gust squashed my head into the ground, and I felt my cheek pressing into the ice beneath the tent. The mountain trembled like a volcano about to explode. The furious howl pinned us for 20 or 30 seconds, and I remember thinking to myself, *Is this what it feels like right before you die?* The tent poles cracked, and I was blanketed in frost-covered nylon that snapped in my face as jagged bits of broken pole cut the yellow nylon into ribbons. I prayed that the bamboo pickets securing us to the mountain would hold.

When the sun finally rose, I sat up, propping the crumpled tent with my throbbing head. My two teammates were curled in the fetal position next to me, and I nudged their legs to make sure they were still alive. When I crawled out of the tent, a scene of utter devastation took my breath away. Every tent was smashed and broken, and one, which had taken off like a kite, was flying in the air about 500 feet above us.

I glanced up at the ridge and saw a group of Indian climbers descending toward our camp as another gust hit. Suddenly, everyone was yelling. Four people hung over the lip of a thousand-foot ice wall, like a string of Christmas lights. One member of our team dived onto the picket that was holding the near end of their rope and hammered in his ice ax to back it up, while others used a

DRESSED FOR THE SUMMIT

Advanced fabrics and materials make much of today's high-altitude gear stronger, warmer, lighter, and more reliable than the technology and clothing available to Mallory and Irvine in 1924. But their gear, heavily influenced by polar explorers, was cutting-edge at the time.

MORE OXYGEN

Mallory's 20-pound, two-tank system held 1,070 liters of oxygen—good for about nine hours. One modern tank weighs the same but holds twice the oxygen.

WARMER CLOTHING

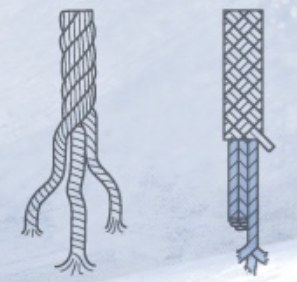
In 1924 climbers layered natural materials such as silk and wool for warmth. Modern breathable synthetic materials dramatically improved wind- and waterproofing.

NEW HARNESSES

Early climbers tied rope around their bodies for safety. Before Mallory's rope snapped, the tug caused rib damage, unheard of with modern harnesses.

STRONGER ROPE

Twisted flax ropes had little stretch and could easily snap. Today's ropes are more than twice as strong, lighter, and more durable, and stretch to absorb falls.



Twisted natural fiber

Braided nylon with core

LIGHTER AXES

Once used to cut steps into the ice, axes today are carried mainly to prevent and arrest falls. Fixed ropes and crampons eliminate the need to cut steps.

HIGH-TECH FOOTGEAR

A thick felt midsole insulated Mallory from cold boot nails. Modern boots are waterproof and better insulated, and feature built-in gaiters.

Flat nail

V-nail

MONICA SERRANO, NGM STAFF; SCOTT ELDER. SOURCES: MIKE PARSONS, MARY ROSE, PETE ATHANS, AND JOCHEN HEMMLEB

The rugged Vest Pocket Kodak camera that Irvine likely carried in 1924 has never been recovered.

Found on the Northeast Ridge in 1933, this ice ax was identified as Irvine's by notches in the wood.

second line to pull the climbers back to safety.

"Let's get the hell out of here," I said.

WE HAD BETTER LUCK with the drones a week later. In one last effort to search the Yellow Band from the air, we climbed back up to the North Col and watched in suspense as Ozturk launched a drone toward the summit. As the craft rose into the thin air, I hovered over his shoulder, directing him where to go and what to take pictures of. By the time the wind started to build in the afternoon, he'd shot 400 high-resolution images of the search area, including a close-up of Holzel's spot.

In one of the photos, I spotted the crevice but couldn't see into its interior. Was Irvine's body inside? We were running out of time to find out.

The first window to reach the summit from the Chinese side opened on May 22 while we waited at Advanced Base Camp. After two trips to the North Col, we were now fully acclimated, ready to set out for our search area high on the Northeast Ridge. But we were far from alone on the mountain. More than 450 people were poised to make an ascent from the Nepali side of the mountain, where Base Camp had turned into a famously commercialized circus. Another 200 or so waited on the Chinese side with us. McGuinness took one look at this summit-hungry crowd and said no. We would wait for the next window.

Over the next several days, nine people lost their lives on Everest, seven on the south side and two on the north (two had died a week earlier on the south side, bringing the total to 11). I'll never forget the helpless feeling of watching through high-powered binoculars as the conga line of a couple hundred hopeful climbers trudged its way toward the summit and reports trickled in over our radio of some of the unfortunate souls who would never return home to their families.

On the afternoon of May 23, we sat down with our climbing support team to discuss logistics for the search. McGuinness had assured us that the team were familiar with our plan, but apparently something had been lost in translation. When I described our strategy to search the Yellow Band for Irvine's body, they threw up their arms and began arguing in Nepali.

"We aren't going to the summit?" Lhakpa Sherpa asked. "Big problem."

Ozturk translated for the rest of us. Number one, the support team didn't want us to go off the fixed ropes set by the Chinese. It was too dangerous and against official instructions, they said. Number two, the summit was important to them. Some of our team were rookies who had never summited Everest. Number three, they wanted to spend as little time as possible at Camp III, which is around 27,000 feet, well into the Death Zone, where the air is too thin to survive for long. "Very dangerous for everyone," they said.

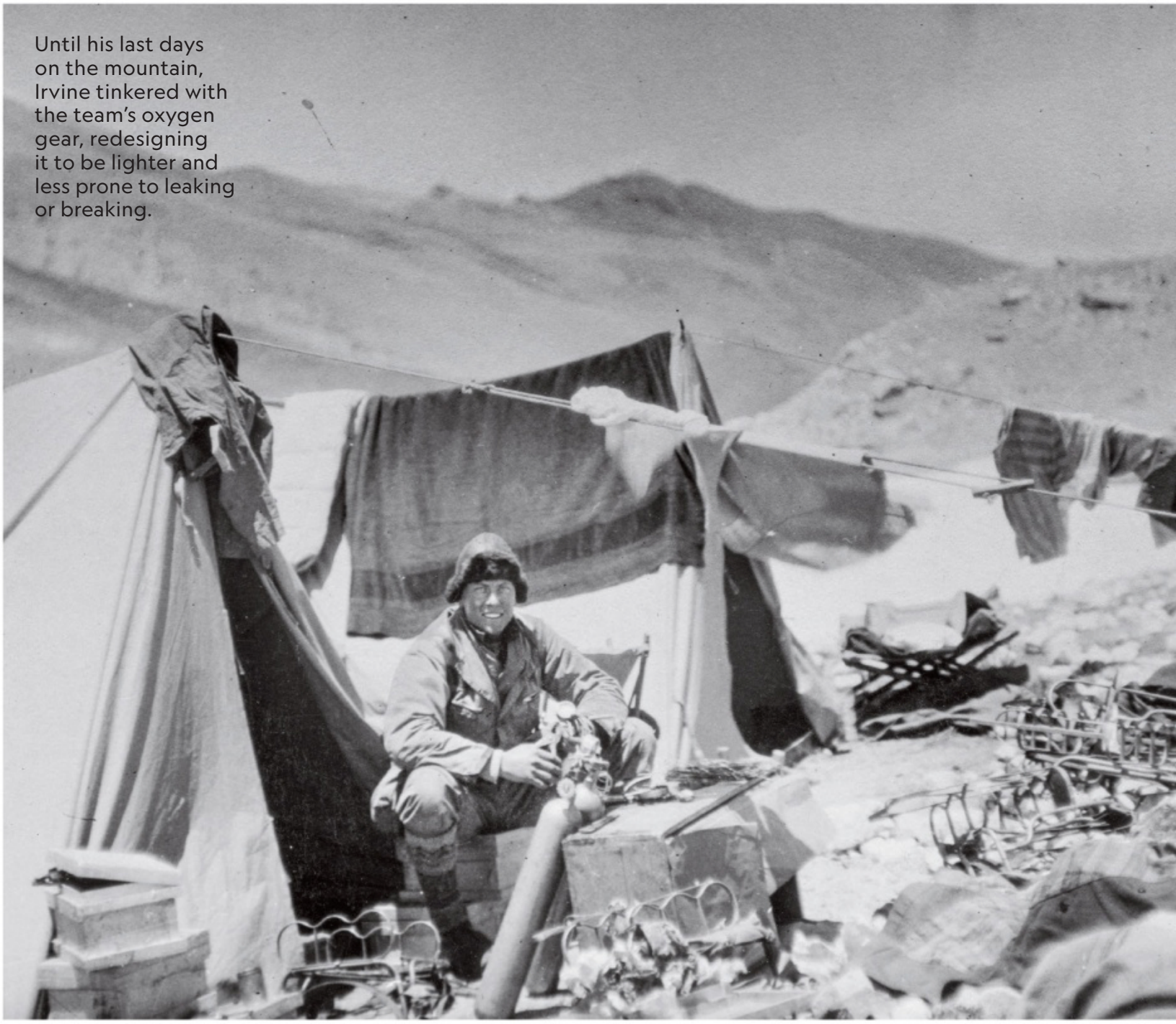
I turned to McGuinness. "What gives? I thought you told them about the search."

He shrugged, barely able to speak because of laryngitis. He indicated that he had indeed discussed the plan with at least some of our support team back in Kathmandu.

There was no way around the fact that we were now on thin ice with our support team, which totaled 12 men. And no one had any illusions about whether we could climb the mountain without them. Like virtually every other team, we were dependent on their support, and if they walked away, our expedition would be over.

MARK THIESSEN, NGM STAFF (CAMERA); AARON TILLEY (AX)

Sucking deeply on their oxygen masks in the thin air of the Death Zone, Irving (at left) and Synnott follow a fixed line to the Northeast Ridge at an elevation of about 27,000 feet—higher than all but five mountains in the world.



Until his last days on the mountain, Irvine tinkered with the team's oxygen gear, redesigning it to be lighter and less prone to leaking or breaking.

"If we went to the summit, could I veer off the established route to search the Irvine crevice on either the way up or down?" I asked McGuinness.

"On the way down would be better," he said. Plus, that way, the terrain would appear the same as it did to Xu Jing back in 1960, when he claimed to have spotted the body.

When we called Lhakpa into the dining tent and told him we were going for the summit, he nodded and said OK in Nepali. No one explicitly mentioned the possibility that I might go rogue on the descent, but I assumed Lhakpa understood, considering that a few minutes earlier we'd told him it was our primary objective. We saw our plan—to go for the summit and then do the search on the way down—as a reasonable compromise.

EIGHT DAYS LATER, our team reached the top of the world and began our descent. Lhakpa, who was bringing up the rear, watched me carefully as I studied the terrain and frequently referenced my GPS. When I unclipped from the rope at 27,700 feet, he shouted, "No, no, no!"

I stood there, trying to decide what to do. In my heart I knew it was wrong to go against Lhakpa and that I was acting like one more selfish Westerner. If I fell or disappeared, Lhakpa would be obliged to go look for me. And if I died, he would have to explain to Chinese officials

what happened. More important, by this point in the climb, I felt he genuinely cared about me. And the feeling was mutual. But here's the thing: I knew I could pull it off. And that Lhakpa would forgive me this indiscretion.

According to the GPS, the Irvine crevice was now within a stone's throw. As Lhakpa and the others looked on, I set off across a narrow ledge covered in plates of loose limestone that covered the ground like paving stones. A few feet out, I stepped on a chunk that slipped out from under my foot, and I wobbled.

"Be careful!" Ozturk yelled.

After traversing about a hundred feet, I looked down and saw a shallow gully cutting through a steep band of rock to the next snow ledge below. I vaguely remembered this feature from the drone photos of the terrain. Was this where Xu had taken his shortcut down through the Yellow Band?

I turned to face the slope, positioning myself as one would to climb down a ladder, and jammed the pick of my ice ax into the rock-hard snow. The steel blade squeaked as it punctured the wind-blasted surface. Looking down between my legs, I took in the dizzying void between me and the glacier far below. Several hundred feet beneath me was the snow terrace where Mallory had been found. I was now more or less directly above his resting-place, on a part of the mountain where people don't go if they want to return home alive. I checked the GPS once again. The arrow on the compass pointed northwest. Fifty more feet.

After down-climbing a few body lengths, I paused on a shattered block of pale brown limestone. The cliff was about eight feet high and as steep as a playground slide. It would have been inconsequential almost anywhere else, but up here, in my depleted state, alone and without a rope, it scared me. I looked up the gully and thought about climbing back up the way I had come. Prudence dictated that I turn back, but my curiosity was stronger. With the pick of my ax still in the snow, I stepped down onto the rock, where my crampons skittered, making a scratching noise like fingernails on a chalkboard.

At the bottom of the cliff, I took a few deep breaths. Ten feet to my right was a small alcove hemmed by a rock wall a bit taller and steeper than the one I had just climbed down. The middle of the wall was striped with a vein of dark brown rock with a narrow crack in the middle. The GPS said I'd arrived. That's when it hit me: The dark rock was the "crevice" we had seen with the drone. Apparently it was an optical illusion. The crack in the center was only nine inches wide. Far too narrow for a person to crawl inside. And it was empty. *He's not here.*

The slope was too steep for me to sit down, so I planted my right foot sideways in a patch of snow and leaned my left knee against the mountain. Hunching over my ax, with my chin on my chest, I sucked on my oxygen mask, trying to clear the fog from my head. When I looked back up, blinking in the midday sun, the crevice was still empty. High above, the summit shimmered against a pale blue sky, immutable and indifferent, as always, to those who sought to unlock its secrets.

We had run down every lead and scoured the mountain slopes with drones, and I had risked my life to solve one of Everest's greatest mysteries. And like everyone else who had ever tried, we were left with more questions than answers.

A pair of sleeping bags crossed in the snow signaled to teammates in 1924 that all hope was lost of finding Mallory or Irvine.

What happened to Irvine that day? Where did he finally come to rest? Had someone removed his body from the slope, or had the jet stream or an avalanche swept it into oblivion?

To all of these questions, I had no answers. But I had learned something about the pull of Mount Everest that drives people to push themselves so hard, because if I hadn't walked in Sandy Irvine's footsteps, I never would have felt it myself. The only thing I could now say for sure was that the mystery of Mallory and Irvine would endure—perhaps forever. And that was OK. ▯

Adapted from *The Third Pole* by **Mark Synnott,** to be published spring 2021 by Dutton, an imprint of Penguin Publishing Group. Copyright © 2021 by Mark Synnott. **Renan Ozturk** photographed honey hunters in Nepal in the July 2017 issue.

BENTLEY BEETHAM, MOUNT EVEREST EXPEDITION 1924 (ABOVE LEFT)
ROYAL GEOGRAPHICAL SOCIETY (BOTH)

THE ROOF OF THE WORLD ISSUE

PAGE 70

JULY 2020

THE LOOMING CRISIS OVER WATER

BY **ALICE ALBINIA** PHOTOGRAPHS BY **BRENDAN HOFFMAN**

The Indus, one of the world's mighty rivers, depends on glaciers in the Himalaya and neighboring ranges to release a steady flow of ice melt in the spring and summer. It supports some 270 million people. But as warming shrinks the glaciers, the flow in the river will decline beginning around 2050, putting millions at risk—and elevating tensions among India, Pakistan, and China.

NATIONAL ◆ GEOGRAPHIC

CHINA

Pilgrims take selfies last September at Drolma La, the highest point on their 32-mile *kora*—a circular, meditative walk around Mount Kangrinboqe in Tibet. The mountain is sacred to four religions, and four of South Asia's rivers rise from near its cardinal points. The source of the Indus River is a four-day walk north of the mountain.

PHOTOGRAPHY FOR THIS ARTICLE WAS SUPPORTED IN PART BY THE SOUTH ASIAN JOURNALISTS ASSOCIATION.

INDIA

Schoolchildren in the village of Gya, Ladakh, cross a glacial stream that feeds the Indus. The river flows through Ladakh, an arid, high-altitude region in northernmost India, on its westward journey from Tibet to Pakistan. In recent decades climate change has sped up the melting of glaciers that feed the Indus, causing unprecedented flooding. In 2014 a flood from a glacial lake destroyed two houses in Gya.

PAKISTAN

The ice-fed torrent of the mountains spreads to its full breadth in the plains of Sindh in southern Pakistan. The barrage at Sukkur, visible in the distance, was built during colonial times. It funnels Indus water into a network of canals to irrigate crops such as cotton, wheat, and rice in the desert. Along the Indus, the British created what is still the world's largest irrigation system.

CHINA

Nomad children fetch water from the Indus near its source in Tibet. China controls the headwaters of the river. In 2006 it constructed a dam without informing India and Pakistan, which heavily depend on the river.

FROM NEAR MOUNT KANGRINBOQE in Tibet rise four major rivers, which stretch east and west across the Himalaya and down to the sea like the limbs of a venerable water goddess. Where these rivers flow, they define civilizations and nations: Tibet, Pakistan, northern India, Nepal, Bangladesh. How their water is spent has long depended on the people living downstream. How the rivers are replenished depends on two things: monsoon rains and glacial ice melt. Both phenomena, for millennia the preserve of the gods, are now in the hands of humans too.

This article was supported by Rolex, which is partnering with the National Geographic Society to shine a light on the challenges facing the Earth's critical life-support systems through science, exploration, and storytelling.

Rivers emerging from the eastern Himalaya, like the Brahmaputra, are mostly fed by the summer monsoon; their flow may well increase as a warming climate puts more moisture in the atmosphere. But most water in the Indus, which flows west from Mount Kangrinboqe, comes from the snows and glaciers of the Himalaya, the Karakoram, and the Hindu Kush. Glaciers especially are "water towers": They store winter snowfall as ice, high in the mountains, and they surrender it as meltwater in spring and summer. In this way, they provide a steady flow that nourishes humans and ecosystems. Downstream, in the plains of Pakistan and northern India, the world's most extensive system of irrigated agriculture depends on the Indus. The glaciers that feed it are a lifeline for some 270 million people.

Most of those glaciers are now shrinking. At first, that will increase the flow in the Indus. But if temperatures rise as predicted, and the glaciers continue to melt back, the Indus will reach "peak water" by 2050. After that, the flow will decline.

Humans already use 95 percent of the Indus, and the population of the basin is growing fast. Writing recently in the journal *Nature,* an international group of scientists (supported by the National Geographic Society) analyzed glacial water towers worldwide. The Indus is the most critical, they said: Given the region's "high

INDIA

A roadside café in Jammu and Kashmir looks out over the Baglihar Dam on the Chenab River, a major Indus tributary. Under the 1960 Indus Waters Treaty, Pakistan was granted use of the waters of the Indus, Chenab, and Jhelum Rivers—but India is allowed certain rights, including electricity generation.

baseline water stress and limited government effectiveness," it is "unlikely that the Indus … can sustain this pressure." Pakistan will suffer most.

From 2003 to 2006, I traveled the 2,000-mile river, from the Arabian Sea to its source in Tibet, researching my book *Empires of the Indus*. Already it was clear that it was under strain. The Indus had changed out of all recognition from the mighty river described by British colonial officials. It had been diminished by the demands of irrigation, industry, and daily life. Because of dams and barrages, it no longer reached the sea, and its mangrove-forested delta was dying. Its lakes were polluted with effluents and sewage.

I was struck by how the Indus, celebrated from ancient times in sacred Sanskrit hymns, was treated as a resource but no longer as an object of reverence. Everyone I met, from peasants to politicians, thought the river was being mismanaged. They spoke of corrupt or inefficient engineering projects, inequitable water sharing, and ecosystems destroyed in the name of profit.

At the time, not many people were talking about the effect of global warming on the Indus. It wasn't until 2010 that the scale of the problem became clear—through dramatic floods rather than a shortage. The future of total rainfall in the Himalayan region is uncertain, but there has been a clear increase in extreme rains. In August 2010, when the Indus was already full of summer meltwater, it was hit by a freak monsoon. The torrential rain—in some places, a year's worth in a few hours—caused the river to breach its banks throughout its southern course. More than

INDIA

Linemen connect a house to the grid in Saboo, Ladakh. The Indian government has promoted hydroelectric developments in the Indus Basin, at huge cost and with great environmental impact—but also benefits. In 2013 Leh, Ladakh's capital, replaced diesel generators with cleaner hydroelectricity.

1,600 people died; damages reached $10 billion.

"Flooding on that scale was unheard of," said Usman Qazi, an Islamabad-based disaster-relief expert with the United Nations Development Programme. "But it will become more common," he added. "Climate change–related floods are one of the biggest hazards in this country."

This is the starkest difference since I wrote my book: The specter of climate change now haunts all discussions of the future of the Indus. The challenge is made infinitely more complex because the Indus and five of its tributaries are shared by India and Pakistan, neighbors and enemies since 1947, while China controls the headwaters. When I reached Tibet in 2006, on my journey to the source, I was shocked to find that there was no water in the Indus: China had recently dammed the river's upper reaches.

India, Pakistan, and China have huge populations and abundant reasons to protect their resources. All three have nuclear weapons. We think of climate change as happening in increments, almost imperceptibly. But along the Indus, it could trigger a conflict that changes the world overnight.

There was a time when humans were so grateful for rivers, they made them into divinities.

In the Rig Veda, India's most ancient Sanskrit text, the Indus is the only river worshipped as both god and goddess, father and mother—probably because it was here, in the Indus Valley, that Hinduism took its first form, experts believe.

North of Kangrinboqe, the great river bubbles modestly out of the ground, as if that four-armed goddess were breathing out. It runs west through the mountains, along the top of India, and across the disputed border into Pakistan. Where the Himalaya meets the Karakoram and the Hindu Kush, in a knot of stone and ice, the river makes a sharp left and is funneled south, a thousand miles through the plains of Punjab and Sindh to the Arabian Sea.

About 40 miles north of that turning point, in the valley of the Hunza, an Indus tributary, I walked onto Ghulkin, a glacier with orchards and villages on either side. It was black with dirt and rubble from the mountains. I stepped over creaking crevasses; with my fingers I touched the ice body itself. From the summit, the view was exhilarating. The torrential brown river cut its way through the valley. Leading down to it were exquisite strips of psychedelic green, fields and orchards in which every leaf is watered by irrigation channels connected directly to the glacier.

In northern Pakistan, Islamic monotheism manages to coexist with a shamanistic appreciation of glaciers' power. I was told many times that Ghulkin was a male glacier, "advancing down the valley in search of a female mate"—that is, a retreating glacier—in a mystical courtship dance. Glaciers advance, local people said, because they're accumulating mass. That's true—but as I learned later from glacial geologist Bethan Davies at Royal Holloway in London, a glacier also can slide downhill like a child's sled because it has started to melt and come unstuck.

That may be what happened in 2018 to Shishper, another glacier nearby: It suddenly began sliding toward the town of Hassanabad, advancing as much as 120 feet a day. "It looked like a train," local geologist Deedar Karim told me. Shishper rolled over irrigation channels and crashed into a bridge. By the time I saw it last October, it had slowed to a foot a day—which is still fast for a glacier.

In the upper Indus Basin, glaciers no longer advance or retreat glacially. The Hoper and Barpu Glaciers have melted back so far that settlements and their laboriously constructed irrigation networks have been drained. You see them abandoned on the mountainside: houses the same soft brown as the dry hills. "They were cultivating fields and trees there in my childhood," said Niat Ali, a 60-year-old ex-army man. He reeled off a list of defunct settlements: Shishkin, Hapa Kun, Hamdar, Barpu Giram.

Melting glaciers also present a more urgent threat. Sometimes the meltwater pools behind a dam of rock rubble or ice—which can explode, unleashing a "glacial lake outburst flood," or GLOF. In 2018, in the Ishkuman Valley, a flood submerged the villages of Bad Swat and Bilhanz. Nayab Khan, 48, felt the land shaking as "the water brought huge boulders. The boulders were colliding. It continued for 12 days." The debris dammed the Immit River, forming a new lake, 20 feet deep, that destroyed his home and 41 others.

Climate change has helped put seven million people in northern Pakistan at risk of such floods. The three glaciers near the village of Pasu "are the three dragons," said Ashraf Khan, an apple farmer and teacher. "We are living in their mouths." In 2008 one dragon unleashed a GLOF in winter, when "normally everything is frozen solid." Last August, summer meltwater "washed away a hotel, an office of the Pakistan Army's intelligence bureau, and an orchard."

INDIA

A nursery in Sichewali, Punjab, cultivates native plants that can serve to green the landscape and allow underground aquifers to recharge. Groundwater reserves in Punjab have been seriously depleted in part by flood irrigation of rice, which was introduced to the region in the 1960s, during the green revolution.

The villagers of Pasu, like everybody else in the north, can see the weather is changing. The summers are now so hot that for the first time in their lives, people are ordering fans from downcountry. The winters are milder, for which most seem grateful. The gold panners who migrate to Hunza seasonally, living in tents along the river, celebrate the warmer weather—even the floods. "The floods bring more minerals out from the rocks," Mahboob Khan explained. He was sieving sand from freezing river water, then rolling it with toxic mercury in his palm to extract specks of gold. He didn't care about climate change.

I was astonished by how few people I met in northern Pakistan knew what was melting their glaciers or blamed the rest of the world. Farther south, in the big cities, a sense of injustice is

crystallizing. Pakistan, a developing country of about 230 million, ranks only 144th out of 192 countries in per capita greenhouse gas emissions. As Pakistan's climate change minister, Malik Amin Aslam, put it to me: "It's not because of us, yet we are bearing the brunt."

WATER SHORTAGES ARE AT CRISIS LEVELS. IN INDIA'S PUNJAB, **DEBT DRIVES ABOUT A THOUSAND FARMERS TO SUICIDE EVERY YEAR.**

WHEN INDEPENDENCE was declared in 1947, and the Partition of the old British colony created India and Pakistan, each country got less of the Indus than it wanted. The long, westward-flowing stretch in the north lies in the former princely state of Jammu and Kashmir, and both new countries wanted all of that. The border dividing Kashmir remains tensely disputed.

Downstream in the fertile plains of Punjab, the British had built dams and barrages on the Indus and its tributaries and diverted water from those headworks into a vast web of irrigation canals. In Punjab the new border cut through five tributaries, giving Pakistan most of the farming settlements around the canals but leaving India with the headworks at Firozpur, on the Sutlej River.

PAKISTAN

UNDER STRAIN FROM SOURCE TO SEA

In the northern mountains, the Shishper Glacier, black with rubble, surged into pipes and other infrastructure in 2018. The surge may have been triggered by accelerated melting.

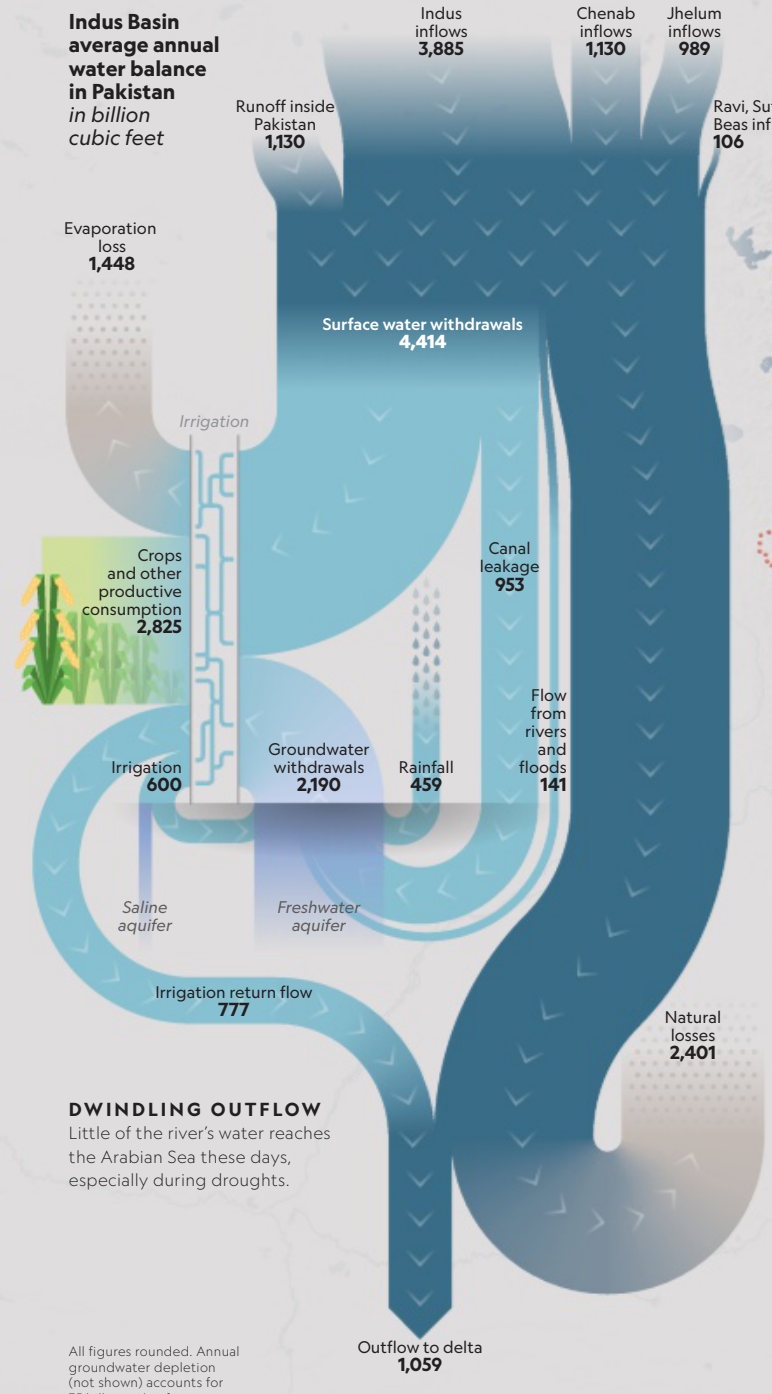
In Karachi (top), on the Arabian Sea, a driver drains water piped from the Indus into his truck—legally, in this case. But a thriving black market leads to dire shortages for the poor.

At his farm in Sindh (above), Abdul Qadir Palari makes the blue for jeans from indigo. It's a native plant that is drought tolerant—unlike cotton, which sucks up a lot of Indus water.

WORRYING WATER USE

About 60 percent of water from the Indus and its tributaries is withdrawn for human use; a third of that evaporates from irrigation canals and flooded fields. Flow is also taken up by natural ecosystems as the river winds through semiarid plains.

Indus Basin average annual water balance in Pakistan
in billion cubic feet



All figures rounded. Annual groundwater depletion (not shown) accounts for 35 billion cubic feet.

DWINDLING OUTFLOW
Little of the river's water reaches the Arabian Sea these days, especially during droughts.

GLACIER CRISIS
In the Indus River Basin 18,495 glaciers help supply water to the river. Climate change has accelerated glacial melting in the Himalaya, adding to the risk of future water shortages.

IRRIGATION DEPENDENCE
Compared with China and India, Pakistan is more heavily reliant on irrigation. That makes agricultural production in Pakistan more vulnerable to diminished flow from the Indus and its tributaries.

WATER POLITICS
Increasing water demand is heightening geopolitical tensions. Disputes over water have flared around India's construction of the Kishenganga and Ratle dams in Kashmir.

MOUNTAIN MELTWATER
Meltwater from snow and glaciers sustains agriculture that provides livelihoods for some 105 million farmers in the Indus Basin.

INDUS LIFELINE

Some 270 million people in four countries depend on the Indus River and its tributaries. But population growth, mismanagement, and climate change all threaten this crucial water supply. North is at the bottom left of this map, which follows the Indus from its source in Tibet (top left) to the Arabian Sea (right).

Cropland
Irrigated · Rain-fed
Built-up area and settlements
Irrigation canal
Dam or barrage

Total glacial area in basin
2,000 sq mi
1,000
500
50

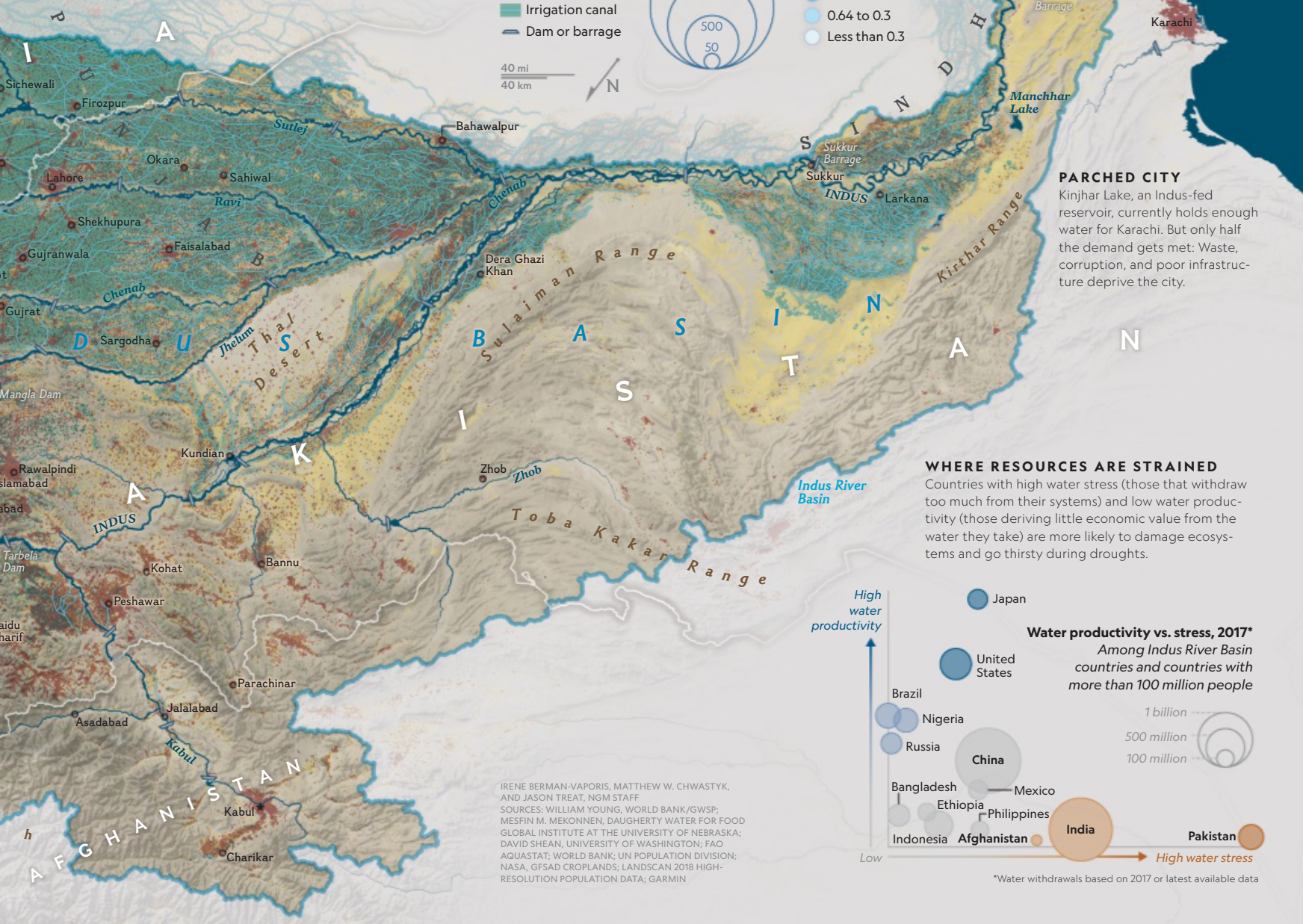
Average glacier mass loss
(feet of water equivalent loss per year)
More than 1
1 to 0.65
0.64 to 0.3
Less than 0.3

40 mi / 40 km

N

sed to produce major crops
feet per ton

	COTTON	WHEAT	RICE	RAW SUGAR
Global average	114,981	67,598 / 70% / 51,900 / 21	47,607 / 23	81,150 / 72% / 50,042 / 29
China	54,046 / 15	57,827 / 65 / 41,200 / 36	25,469 / 36	66,829 / 54 / 44,659 / 4



PARCHED CITY
Kinjhar Lake, an Indus-fed reservoir, currently holds enough water for Karachi. But only half the demand gets met: Waste, corruption, and poor infrastructure deprive the city.

WHERE RESOURCES ARE STRAINED
Countries with high water stress (those that withdraw too much from their systems) and low water productivity (those deriving little economic value from the water they take) are more likely to damage ecosystems and go thirsty during droughts.

Water productivity vs. stress, 2017*
Among Indus River Basin countries and countries with more than 100 million people

*Water withdrawals based on 2017 or latest available data

IRENE BERMAN-VAPORIS, MATTHEW W. CHWASTYK, AND JASON TREAT, NGM STAFF
SOURCES: WILLIAM YOUNG, WORLD BANK/GWSP; MESFIN M. MEKONNEN, DAUGHERTY WATER FOR FOOD GLOBAL INSTITUTE AT THE UNIVERSITY OF NEBRASKA; DAVID SHEAN, UNIVERSITY OF WASHINGTON; FAO AQUASTAT; WORLD BANK; UN POPULATION DIVISION; NASA, GFSAD CROPLANDS; LANDSCAN 2018 HIGH-RESOLUTION POPULATION DATA; GARMIN

Officials on the Indian side asserted their power immediately in spring 1948, shutting the gates of the headworks. That sharply reduced the flow into Pakistan. The gates reopened after a few weeks. But as Majed Akhter, a geographer at King's College London, told me, that experience of Indian willfulness is the "founding violence" for Pakistani officials. Last October, Indian prime minister Narendra Modi threatened to cut the flow again.

Pakistan got some reassurance in 1960, when the World Bank persuaded both countries to sign the Indus Waters Treaty. The treaty divided the river basin, awarding water in the Indus and two western tributaries to Pakistan, with the three eastern tributaries going to India. The international community pushed the countries to build more dams and canals. Pakistan completed the Tarbela Reservoir in 1976. India finished the 400-mile Indira Gandhi Canal in 1987 to carry water and the green revolution from the Punjab south as far as Rajasthan's Thar Desert.

Analysts in both countries agree that the canals, by providing copious water at artificially low cost, encourage waste. "We grow paddy in the desert!" exclaimed Ali Tauqeer Sheikh, a member of Pakistan's National Climate Change Council. But "100 years on, we can't keep blaming the British." Large farmers, he said, are "the political elite and simply refuse water pricing."

PAKISTAN

In Wagah, Punjab, visitors pose with soldiers following the elaborate daily closing ceremony on the border with India. In 1947, when two independent countries were created from British India, the province of Punjab was divided down the middle. For the two Punjabs, as for the two nations, Indus Basin water is a prime source of tension.

Water shortages on both sides of the border are at crisis levels. In India's Punjab, debt drives about a thousand farmers to suicide every year. Pumping groundwater is expensive; every year they have to bore deeper wells as the water table falls—to 400 feet in some places. The groundwater depletion is caused by the growing of rice, a thirsty crop. Meanwhile, river water is shipped away as far as Rajasthan.

Across the border from Rajasthan, in the Pakistani province of Sindh, I traveled to a canal-irrigated part of the Thar Desert. The irrigation water was coming from nearly 200 miles away—from the barrage at Sukkur on the Indus, built in 1932 by the British. Here, at the end of the canal system, women and children were out in the fields, harvesting the famous Dundicut chili. In the open-air chili market of Kunri, the biggest in Pakistan, my eyes watered as I watched mountains of vivid red fruits being auctioned.

But the 2019 harvest was a dud, explained Mian Saleem, president of Sindh's Red Chillies Growers Association: Extreme weather had cut the yield by two-thirds. In May the temperature reached 117 degrees, withering the crop. "In 40 years, I never felt such heat," Saleem said. Then came "rain in October for the first time in my life." Picking was delayed, and the fruit rotted.

In the village of Rano Khan Rahimoon, I spoke with landless sharecroppers, Hindus and Muslims living side by side in painted mud-walled houses. They grow chilies and other cash crops, and they were eloquent about their biggest problem: water. "Sometimes the canal water comes, sometimes it doesn't," said Attam Kumar, 28.

"The problem is threefold," he went on. "Scarcity of canal water, unusually heavy monsoons, and this poisoned groundwater we are forced to drink." Wells, he said, have been contaminated by runoff from fertilized fields. Kumar pulled up the shirt of Salaam, an 11-year-old boy, to show me the scar from his kidney surgery. Four of the 150 villagers have had kidneys removed. "This poison is shortening our lives," Kumar said.

The next morning I took tea with a landowner and former federal minister, then spoke with the manager of a 6,000-acre mango farm, where servants were watering a rose garden in the desert. Both men lamented the newly erratic weather as they cracked open bottles of Evian. But they weren't worried about running short of canal water; they were powerful enough to be given what they needed.

After a delicious lunch at the mango farm, I stopped by the village hospital. The doctor, Moomal Waqar, was in despair about the number of patients with kidney and gallstone ailments. Like the sharecroppers, she blamed unfiltered drinking water polluted by fertilizer. "Who here," she asked, "can afford mineral water bottles?"

POISONED WATER is widespread in Pakistan. A team led by Joel Podgorski of the Swiss Federal Institute of Aquatic Science and Technology reported in 2017 that up to 60 million people in the Indus Basin may drink groundwater contaminated by arsenic. The arsenic is naturally present in soils; it may also come from fertilizers. It gets leached into the aquifer by heavy irrigation.

"Arsenic poisoning exactly matches the

PAKISTAN

A truck delivers cotton to a textile factory in Sindh. The textile industry as a whole accounts for 8 percent of Pakistan's GDP and more than half of its foreign exchange earnings. But cotton is a water-intensive crop, and in recent years, erratic weather patterns—heat waves followed by unusually heavy rains—have resulted in low yields.

irrigated areas," said Hassan Abbas, a hydrogeologist in Punjab. "We have poisoned one of the largest groundwater reserves in the world."

Pakistan also has one of the world's highest rates of childhood malnutrition—at least a third of all children suffer from it. The country's highest rates of all, said Daanish Mustafa, a Pakistani geographer at King's College London, are "in the irrigated districts," where agricultural practice prioritizes export crops over food security.

All these problems come back to the way water is used in the Indus plains. Dams, barrages, and canals made water abundant and cheap while trapping much of the river's fertile silt in the reservoirs. The green revolution in the 1960s and 1970s brought even thirstier hybrid crops, along with chemical fertilizers and pesticides. Flood irrigation requires lots of both, because standing water is a vector of insect pests and because the water washes the chemicals away—into groundwater. The result, according to Abbas, is that "we now take 10 times more water from the river than we need to." Water is scarce and contaminated in a land where it was once plentiful and clean.

Like many water experts I spoke with, Abbas advocates a radical overhaul of the system. Both Pakistan and India have ancient water-harvesting traditions, adapted to the rhythms of the river and the rains, that have been neglected since British times. Instead the two countries have focused on huge engineering projects—on dams and canals. Both have plans for new dams in the Indus Basin.

Climate change, Abbas argues, could be a blessing for Pakistan—an incentive to rethink

PAKISTAN

Children collect drinking water from a filtration plant on the shores of Manchhar Lake, Sindh. Pakistan's largest freshwater lake, it's fed by the Indus. But water diversions upstream have caused it to stagnate, while agricultural runoff draining into the lake has killed most fish and made the water too polluted to drink without treatment.

the system. It could transition from expensive hydroelectric dams to cheaper solar power. It could replace flood irrigation with drip irrigation from pipes tapping into an unpolluted aquifer under the Indus. Finally, it could restore wetlands and forests in a corridor along the Indus and its tributaries. They would absorb floodwaters, thus avoiding a repeat of the 2010 disaster, and at the same time recharge the aquifers. Dams and reservoirs provide Pakistan with only 30 days' supply in a drought; the Indus aquifer alone has enough water for three years, Abbas calculates.

He thinks rainfall- and river-water capture might even recharge the aquifer under Karachi, Pakistan's commercial capital. On the edge of the Indus Delta, it's one of the world's largest water-stressed cities: Fifteen million people have sucked its aquifer dry. Kinjhar Lake, an Indus-fed reservoir 60 miles away, is their nearest source.

BY THE TIME the river nears the sea, it has almost ceased existing. In an alley in Goth Ibrahim Haidri, a fishing village near Karachi, I passed a line of women waiting with their water-pots for a tank truck. They said they'd been waiting for three days. Such scenes are common in low-income neighborhoods here. The rich take the lion's share of freshwater from the Indus and its lakes, often buying it illegally. The poor wait in line or buy cheaper, brackish water.

Many residents of Goth Ibrahim Haidri are migrants from the delta. Their ancestral home was ruined from two directions. Since the Ghulam Muhammad Barrage was constructed in 1955, the Indus has flowed down to the sea only weakly, fitfully; instead, boosted by climate change, the sea has risen to meet the river, rendering it salty far upstream.

At sunset I stood by the sea watching the pretty wooden fishing boats come into harbor. Like Pakistan's trucks, they were painted in a riot of colors, adorned with flowers and fish. Mohammad Ali Shah, head of the Pakistan Fisherfolk Forum (PFF), grew up here and swam in this sea as a child. He would never let his grandchildren do so, he said—it's far too polluted.

PFF is campaigning for a law that would grant personhood—and rights—to the Indus. Shah showed me a draft. It calls the Indus "an ecological marvel" with "value aside from its utility to humans." It points out that the Quran calls all the Earth "a mosque." It proposes checks on hydro projects, pollution controls, and a fund to restore the river.

The proposal is too radical to become law. But something needs to shift along the Indus; something like the old reverence needs to return. The alternative, in which the river continues to be squandered and new weather gods add to the chaos, is too scary to contemplate. □

Alice Albinia, author of *Empires of the Indus* and other books, lives south of London. **Brendan Hoffman** lives in Ukraine. For both this is the first time contributing to the magazine.

THE ROOF OF THE WORLD ISSUE

JULY 2020

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MAKE YOUR OWN GLACIERS

BY **ARATI KUMAR-RAO** PHOTOGRAPHS BY **CIRIL JAZBEC**

What do you do when the snows you depend on for water are melting too quickly, and glaciers have receded high into the mountains? At the northern tip of India, the people of Ladakh are dealing with climate change by creating huge cones of ice that give desperate farmers water when they need it.

NATIONAL ◆ GEOGRAPHIC

Conical ice stupas serve as water towers, storing winter meltwater for spring planting. The youth group that built this one in the northern Indian village of Gya also installed a café in its base. They used the proceeds to take village elders on a pilgrimage. “No one takes them anywhere,” one of the youths said.

ICE CAFE

LADAKH, A HIGH PLATEAU at the northern tip of India, beyond the Himalaya, is under attack. The enemy is cutting off its water sources, drying its farmlands. Desperate farmers, who long raised pashmina goats, wheat, and barley on the arid land, are fleeing to Leh, a city on the Indus River. Sonam Wangchuk and I are driving over passes and valleys above 9,000 feet to inspect his defenses: tall cones of ice that he calls stupas.

"This enemy wears no uniform, bears no allegiance to any nation-state, and carries no automatic weapons," says Wangchuk, an engineer who also founded an alternative school in Ladakh. "Undeterred by borders, it bides by no international laws. We Ladakhis are on the front lines of a very different war."

The enemy is climate change. A rise of around

Gyen Rigzen, manager of the monastery in the village of Phyang, holds a chunk of ice from the stupa built there in 2019. As it melts, the monks use the water to sustain a grove of 5,000 willow and poplar trees they planted five years ago, after their first stupa was made.

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MAKE YOUR OWN GLACIERS

one degree Celsius (1.8 degrees Fahrenheit) in average winter temperatures during the past four decades has severed a crucial link in Ladakh's water cycle. Wedged between Pakistan and India, shielded by the Himalaya from the southwesterly monsoon, Ladakh averages only four inches of rain a year. Its lifeblood is winter snows and glaciers in the mountains. The snows, however, have become fickle, melting before the spring planting, while the glaciers have retreated far up the mountains and are melting later.

"The gap between a late winter snowmelt and springtime glacier melt is yawning ever wider," Wangchuk explains. That gap, that drying of spring, is making agriculture impossible. "We have a negligible carbon footprint, but we are bearing the brunt of a changing climate," he says. Ladakhis can't stop climate change—but ice stupas might bring back some water in spring.

AS WE TURN OFF the highway and up a gorge near the Pakistani border, Wangchuk tells me his story. In 2013 he noticed that ice, even at a low altitude and at the height of summer, stayed frozen in the shade of a bridge. He realized that he could help villages freeze water in winter for use in spring. Shading vast expanses of ice was impractical, but a tall mound would shade its own interior—and the steeper the sides, the better, because that reduces the area exposed to the sun. "High school math told me that a cone

The nonprofit National Geographic Society, working to conserve Earth's resources, helped fund this article.

TOP LEFT

Shaded by mountains, the stupa near the village of Lamso lasted well into summer—tiding farmers over until meltwater arrived from natural glaciers that have retreated high in the mountains.

TOP RIGHT

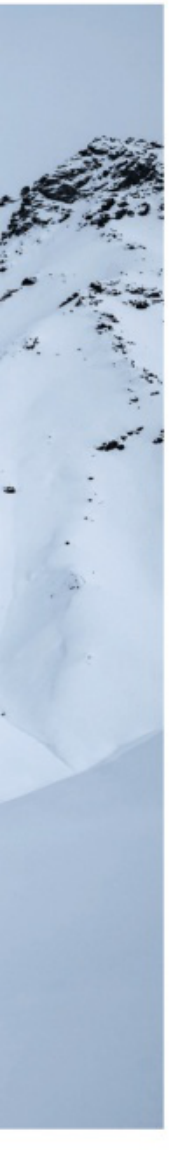
Sonam Wangchuk, inventor of ice stupas, also created an alternative school near Leh, a Ladakhi city. The students have helped build some of the towers. Here a few of them celebrate Earth Day on the stupa at Phyang.

BOTTOM LEFT

A stupa, originally, is a rock mound that Buddhists build as a shrine for relics. In 2019, when the Phyang monks helped make this ice stupa, artists created a shrine inside.

BOTTOM RIGHT

Ice stupas are built in winter by channeling water from a mountain stream into a vertical pipe. Gravity drives the water out a nozzle at the top, and as cold air freezes the falling spray, a cone of ice rises around the pipe. This 80-foot-high stupa is in Gangles, near Leh.



This stupa near the village of Shara Phuktsey won first prize for largest stupa in a 2019 competition. Its nearly two million gallons of stored water helped irrigate fields in four villages. The stupa also drew tourists: Ice climbers came to scale its steep flanks.

18+

WHAT IS AVAXHOME?

AVAXHOME-

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was the simple answer," Wangchuk says as he negotiates a hairpin bend.

In Buddhism, a stupa is a mound of stone or mud that houses revered relics. Wangchuk and his students built their first ice stupa in November 2013. They routed a stream near Leh through a pipe down a mountain, then sent it up a vertical pipe to a nozzle. That's it: Stupa building is not high-tech. Wangchuk's team opened the nozzle at night, when the air was below freezing. The fine spray froze as it fell. Slowly a mound of ice rose around the pipe, tapering toward the top.

That first test stupa was 20 feet high, held 40,000 gallons of water, and lasted until May. Since then, Wangchuk has taught villagers around Ladakh to build stupas. In 2019 they made 12, two of which were more than 100 feet tall. This year they built 26, with nine cresting 100 feet.

Climate change is not only drying springtime in Ladakh; it also is causing flash floods from freak summer rains. Maybe, Wangchuk thinks, irrigation water from stupas could help revegetate hillsides to soak up rain. "If a stupa's size and location are optimal, it might survive the summer into the following winter," he says. "The stupa would grow, year on year," becoming perennial—like a glacier.

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MAKE YOUR OWN GLACIERS

Driving along the precipice, we reach the village of Karith. Wangchuk is welcomed as a hero by students at the middle school. They built the village's first small stupa in 2016. "We want to make the children aware about what is happening in the world and how it is affecting us," says headmaster Mohammad Ali. Wangchuk wants to make the world aware of what it's doing to Ladakh. Stupas are "a wake-up call to change carbon-intensive city lifestyles," he says.

Karith's stupa last year was 73 feet high. Nestled in the shade of a peak, it lasted through August, allowing farmers to water their fields. This year, farmers and students together built a higher stupa. "One day," Ali says, "we will build an ice stupa that keeps growing." ▯

Arati Kumar-Rao, a writer based in Bangalore, India, focuses on water issues. **Ciril Jazbec** has photographed tech entrepreneurs in Africa and Inuit hunters in Greenland for the magazine.

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THE HIMALAYA'S GHOST LEOPARDS

BY **PETER GWIN** PHOTOGRAPHS BY **PRASENJEET YADAV, FRÉDÉRIC LARREY, AND SANDESH KADUR**

For millennia, snow leopards have haunted some of Central Asia's most forbidding terrain—soaring cliffs, plunging gorges, high deserts. Here, thin air, deep snow, and subfreezing temperatures have allowed these obscure cats to elude the human gaze and disappear into the landscape like phantoms. But thanks to conservation, camera traps, and now tourism, they are finally coming into view.

NATIONAL ◆ GEOGRAPHIC

A male snow leopard marks his territory in India's Ladakh region. The cats spray urine, leave scratch marks, and rub facial glands on rocks to signal their presence. Unlike tigers, their closest relatives, snow leopards aren't able to roar. Instead, they puff, meow, growl, and hiss.

SANDESH KADUR

A female watches over one of her two cubs in Sanjiangyuan National Park on the Tibetan Plateau in China's Qinghai Province. The snow leopard's range spans roughly 800,000 square miles across 12 countries in some of the world's most rugged terrain, making it very difficult to study the species as a whole.

FRÉDÉRIC LARREY

THE OLD SNOW LEOPARD was well-known in Kibber. It was unclear when he'd claimed the gorges and cliffs around this ancient Himalayan village, but over the past few years, the people here had come to recognize this large male, with a notched left ear, and kept track of him to the extent anyone could. Like all snow leopards, he was part phantom and would shape-shift, dissolving into these mountains like smoke from the village chimneys, dispersing into the cold, thin air.

The old ones are the ones you must watch. When snow leopards are too old to hunt the ibex and blue sheep that live among the limestone crags, they seek easier prey, the village's goats and sheep, young horses, and yak calves.

On a bitterly cold afternoon in February, I crouched on the ice-encrusted rim of a gaping

A female descends a slope in Sanjiangyuan National Park. Since blue sheep and other prey are plentiful here, she hunts in a relatively small territory of six to 10 square miles. Where the quarry is scarce, a snow leopard may need nearly 400 square miles of territory for hunting.
FRÉDÉRIC LARREY

chasm, watching the old snow leopard through binoculars. He drowsed on a ledge on the opposite cliff, its sheer walls plunging nearly a thousand feet to the Spiti River. A veil of snowflakes as fine as eyelashes drifted into the gorge, and occasionally, when I jiggled the binoculars, the cat's smoky fur with charcoal rosettes would be lost among the creases and shadows. "Crap, I lost him again," I'd whisper. Prasenjeet would look up from his camera and point, and I'd follow his finger back to where the animal lay.

This was, after all, Prasenjeet's snow leopard. Some of the local guides even called him that. When we'd heard a cat had been spotted, one of them said, "It's yours," tapping his left ear.

For the past two years, photographer Prasenjeet Yadav had tracked this male on foot and with camera traps in this high-altitude corner of northern India's Spiti Valley. In the coming weeks we'd trek more than 30 miles, descending into canyons, trudging up snow-choked passes, climbing onto icy cliffs. But today—my first day in Kibber, and still woozy from the climb to 14,000 feet—the cat had deigned to appear.

Ever since college, when I'd read Peter Matthiessen's book *The Snow Leopard,* I'd fixated on seeing one of these elusive creatures. Maybe because Matthiessen never did. In 1973 he and the legendary biologist George Schaller had spent two months hiking in Nepal and had seen signs of the cats—paw prints, scratch marks, scat—but

The nonprofit National Geographic Society, working to conserve Earth's resources, helped fund this article.

never glimpsed one. At the time, Schaller was said to be one of only two Westerners who'd seen a wild snow leopard. In 1970 he'd taken what is believed to be the first photograph of a snow leopard in its natural habitat. For more than two decades, it would be the only such image known to exist of this solitary, obscure animal.

So it was profoundly ironic that as I finally was getting to see a snow leopard, the most prominent sound in my ear was the persistent whir of nearly two dozen cameras, capturing hundreds of images of the cat. On the cliff with Prasenjeet and me were tourists from around the world, most hunched over expensive telephoto lenses.

KIBBER IS THE PLACE TO SEE THE CATS WITH ANY PREDICTABILITY. **BUT THE JOURNEY IS NOT FOR THE FAINT OF HEART.**

In the past few years, Kibber has become the place to see the cats with any predictability. But the journey is not for the faint of heart. The village is reachable only by a zigzagging, single-track road carved into impossibly steep mountains. And you must go in winter, when the snow leopards follow their prey to lower elevations, which means large stretches of the route are covered in snow and ice.

The previous day, as Prasenjeet and I made the drive up, I found myself white-knuckling the door handle as he navigated the icy switchbacks and blind corners. Occasionally we'd see a shower of gravel hit the road ahead, and he'd stop the vehicle and look up the cliff for signs of an avalanche. After a bit, we'd proceed, and I'd grip the door handle tighter.

He explained matter-of-factly that every driver who travels the route with any regularity tells stories of vehicles that had slid off and plummeted to the valley floor or been crushed by falling boulders. Our own journey had been delayed two days when the road was blocked by a landslide. The road department had used dynamite to clear it, only to set off another landslide. "Don't worry," he reassured me. "It's 95 percent safe."

But all my worries were forgotten as we watched the snow leopard, sweeping his thick spotted tail and surveying his domain. Soon whispers passed down the line of tourists and guides. Three ibexes with their scimitar-shaped horns had appeared on the cliff, about 300 feet from the snow leopard. We watched as the cat caught their scent, tensed, and slowly lifted his head. With unhurried, calculated movements, he climbed the escarpment. Frequently he would pause and remain so still that I'd lose him in the binoculars until he started moving again. "He wants to get above the ibexes to chase them to the edge of the cliff," Prasenjeet whispered.

After about 20 minutes, with the sun setting and the temperature well below freezing, the cat had closed to within a hundred feet of the ibexes. The whirring of the cameras stopped, and everyone seemed to hold their breath, waiting for the leopard to break into a sprint. But then a sharp whistle broke the silence, and the ibexes spooked. "That's their warning call," Prasenjeet said. "One of them must've smelled it." Serenely, the snow leopard descended and disappeared from view.

The shivering tourists beamed at each other, high-fiving gloved hands, and followed their happy guides back to Kibber for heaping plates of dal and rice and steaming cups of chai.

"Please, sit closer to the fire," Tanzin Thinley urged me. The wind was snapping a string of frayed prayer flags outside the window, and we were huddled around the wood-burning stove in his living room.

His wife, Kunzung, fussed over me, bringing chai, a yak-hair blanket, and a pair of hand-knit wool socks because she was worried I wasn't warm enough.

Thinley, known to everyone in the village by his last name, wore a battered down jacket, a baseball cap, and the unruffled calm of a man who has

weathered 42 Himalayan winters. He was telling a story that, based on the look on his face, still surprised him: how people in Kibber went from reviling snow leopards to venerating them.

"It began with Charu," he said.

In 1996 Charu Mishra, then a 25-year-old student from Delhi, first arrived in Kibber. It's a small village consisting of a few dozen families who live in mud-and-timber houses clustered on a steep hillside overlooking the Spiti Valley. Once part of a Tibetan kingdom, the village for centuries has hosted a Buddhist temple, where monks mark each midday with chanting that echoes through the valley. The people of Kibber have tended livestock for generations, and like herders throughout the Himalaya, they regard snow leopards as grave threats to their livelihoods.

Charu's plan was to study the impact domestic animals have on wildlife in the Spiti Valley. He rented a room and over two years spent his days surveying the high pastures. He also immersed himself in village life. The high school lacked a math teacher, so at night he taught math. When people fell ill, he drove them down the mountain to a clinic. He did chores, found lost animals, played in cricket matches, joined the youth club. "Parents told their children, 'You can be like Charu,'" Thinley said. "I was in awe of him."

After living in Kibber for a while, Charu asked the village elders to consider setting aside some mountain pastures for wild animals. They agreed, and without the competition from livestock, the number of blue sheep quadrupled. He then suggested some nonlethal ways to deal with the snow leopards that threatened their animals. But they politely declined, Thinley said. "They all respected Charu, but snow leopards were like a curse. No one had sympathy for them."

Undeterred, Charu turned to the young people in Kibber and suggested the idea of a livestock insurance program. "We didn't know what insurance was," Thinley said. Charu explained that the participants would pay the equivalent of five dollars a year to insure their young yaks, worth roughly $340 when mature—against loss from a snow leopard. To prevent false claims, the owner would be asked to swear on the Dalai Lama's photo that a snow leopard had made the kill.

"We weren't sure this was going to work," Thinley said. But at the end of the first year, four claims were paid. "The payments were made in front of the entire village," he said. "When the elders saw this, they all joined."

Since then, the insurance program—run by a board of local residents, including Thinley, and supported by India's Nature Conservation Foundation (NCF) and the Snow Leopard Trust—has spread to other villages in the Spiti Valley.

These efforts led to an increase in snow leopard sightings around Kibber and the arrival of the initial snow leopard tourists in 2015, the first year the road was open in winter. Last year, more than 200 tourists visited, spending approximately $100,000 in the village. Charu, who now heads the Snow Leopard Trust, is careful to credit the locals, with whom he remains in close touch. "I made some suggestions, and NCF put up some funding," he told me when I met him at his office in Bangalore. "But the people in Kibber and the Spiti Valley are the ones who deserve the credit for the conservation successes there."

The number of snow leopards in the Spiti Valley remains unknown. In fact, despite the determined efforts of Schaller and many other scientists, counting them is practically impossible.

Their range extends across 12 Central Asian nations, covering 800,000 square miles of some of the harshest environments for humans. Lung-starving altitudes, frostbite-inducing temperatures, rugged, barren terrain—much of it inaccessible—all limit the amount and quality of scientific fieldwork.

In recent years a research team in Mongolia managed to put satellite collars on 32 snow leopards and learned much about the cats' movements in the Tost Mountains of the Gobi desert. For example, an adult male there requires roughly 80 square miles of territory—an area about three and a half times the size of Manhattan—while a female needs about 48 square miles.

But such figures can't be applied across the vast, diverse snow leopard range. The amount of land a cat needs in the high desert is likely different from what it needs in, say, Siberia. The availability of prey, proximity to humans, and other factors may increase or reduce the range it needs. The Snow

An old male, well-known to the villagers of Kibber, eats a domestic sheep he has killed near their small community in the Spiti Valley in India's Himalaya. Even when snow leopards have access to wild game, they will kill livestock if the opportunity arises.

PRASENJEET YADAV

SNOW LEOPARD REALM

Snow leopards are found only in the mountains of Central Asia. The rugged, inaccessible terrain and cold climate make it difficult to study the species; less than 2 percent of their range has been fully surveyed. Population estimates vary widely—from 3,500 to 7,000 cats.

Current range of *Panthera uncia*
Experts think snow leopards live in these areas.

Range threatened by climate change
Parts may become unsuitable by 2070.

Range prioritized for conservation
A coalition of 12 countries with snow leopards selected these areas as most vital to protect.

DESTRUCTIVE MINES

Open-pit mines devastate natural habitats. They also bring more roads and people—which can mean easier access for poachers.

⚒ Selected mine

RUSSIA
Lake Baikal
Sayan Mts.
Nuurst Khotgor Coal Mine
Ulaanbaatar
KAZAKHSTAN
Khangai Mts.
MONGOLIA
Khushuut Coal Mine
ALTAY MTS.
Tavan Tolgoi Coal Mine
TIAN SHAN
Tost Mts.
GOBI
Bishkek
KYRGYZSTAN
UZBEKISTAN
Kumtor Gold Mine
Alay Mts.
TAJIKISTAN
Pamirs
TAKLIMAKAN DESERT
Altun Mts.
Qilian Mts.
AFGHANISTAN
Hindu Kush
Karakoram
KUNLUN MTS.
CHINA
Kabul
PLATEAU OF TIBET
Sanjiangyuan N.P.
Islamabad
PAKISTAN
Kibber
13,580 ft
4,139 m
250 mi
250 km
New Delhi
HIMALAYA
Lhasa
NEPAL
Mt. Everest
29,035 ft
8,850 m
BHUTAN
MYANMAR
INDIA
BANGLADESH
ASIA
Current range of snow leopards

CHANGING CLIMATE

Rising temperatures will shift the cold alpine areas that snow leopards inhabit. In the Himalaya, one-third of their range could be lost.

THREATENED PREDATOR

Snow leopard survival is closely tied to their cold, harsh habitat and the availability of ibex, blue sheep, and other wild prey. When prey are displaced by domestic animals such as yaks and horses, the cats can turn to hunting livestock. Up to 450 of the cats are believed to be killed annually, mostly in retaliation by herders; some are targeted by poachers, mostly for their skins.

Forests can move higher with global warming, shrinking the habitat used by the cats and their prey and intensifying competition with herders.

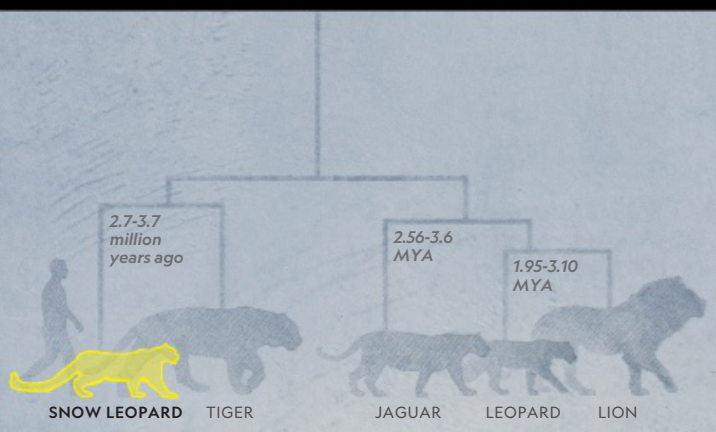
RILEY D. CHAMPINE, TAYLOR MAGGIACOMO, NGM STAFF
SOURCES: KULBHUSHANSINGH SURYAWANSHI AND KOUSTUBH SHARMA, SNOW LEOPARD TRUST; JUAN LI, PANTHERA; TRAFFIC; GSLEP; SNOW LEOPARD NETWORK; WILDLIFE CONSERVATION SOCIETY

BODY IN BALANCE

Adaptations of the tail, limbs, spine, and head help with high-altitude hunts while preserving warmth and energy. Although related to tigers, snow leopards have bodies optimized for agility and speed over brute strength when hunting.

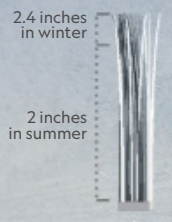
FAMILY TREE

Genetic analysis places snow leopards firmly with the big cats of *Panthera*. They were once thought to be distant relatives due to their unique morphology.



BUSHY TAIL

Snow leopards have the longest tails, proportionally, of the big cats—nearly as long as the rest of their body. At rest, the thick tail warms their legs and nose.



The longest fur of the big cats traps a layer of air near the skin to insulate their bodies in sub-zero temperatures. Fur length varies across the body.

25,800 hairs/ square inch

Coats are tan to gray; dark rosettes help with camouflage.

The tail extends during jumps and counterbalances during turns.

Snow leopards can leap across 50-foot gorges; they can also jump six feet high with no running start.

PRECARIOUS PURSUIT

Snow leopards can jump across ravines, changing direction mid-leap by rebounding off walls, as they pursue their prey in chases that can reach up to 40 miles an hour in the steepest terrain.

They try to catch a large animal every eight to 10 days, consuming it over several days.

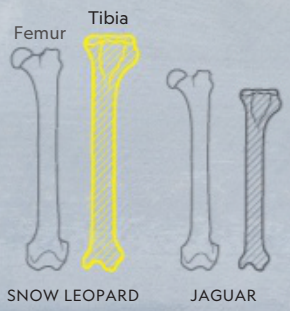
Snow leopard *(Panthera uncia)*

Siberian ibex *(Capra sibirica)*

EXTRA-LONG LIMBS

Like cheetahs, snow leopards have elongated hind limbs for more powerful jumps and faster acceleration than jaguars and other cats. They are also the only big cats with elongated tibiae.

Bone size shown relative to animal's length



*EXACT MAXIMUM ALTITUDE UNKNOWN

MANUEL CANALES, TAYLOR MAGGIACOMO, EVE CONANT, NGM STAFF. MESA SCHUMACHER

SOURCES: ANDREW KITCHENER, NATIONAL MUSEUMS SCOTLAND; TOM MCCARTHY, PANTHERA; JAN E. JANECKA, DUQUESNE UNIVERSITY

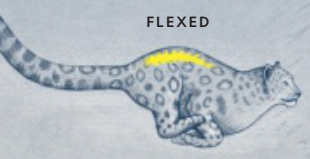
MOUNTAIN HUNTERS

These agile, high-altitude cats have been scraping out a living on the roof of the world for eons—and they have the body to show for it. Snow leopards balance their need for speed and power in pursuit of prey with adaptations to help them cope with steep terrain, low oxygen, and bitter cold.

FLEXIBLE BACKBONE

Snow leopards have a long and flexible lower spine, which lets them expand and contract their backs to cover more ground with each stride.

FLEXED



SPINE EXTENDED IN STRIDE

Thoracic vertebrae

Thick belly fur keeps vital organs warm.

PAW SHOWN ACTUAL SIZE

ADAPTED TO THE EXTREME

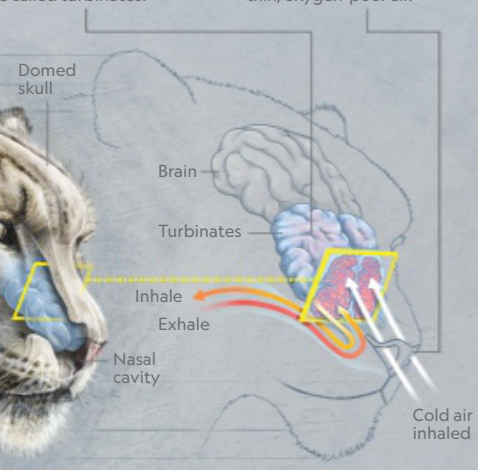
Their harsh environment requires compromise when it comes to anatomy: Small bodies have less force but expend less energy. Domed skulls allow for greater oxygen intake and more surface area for bite muscles than the flatter crania of other *Panthera*.

WARMING AIR

Warm air exiting the lungs heats freezing inhaled air in especially large and dense mazes of bone and tissue called turbinates.

MAXIMUM OXYGEN

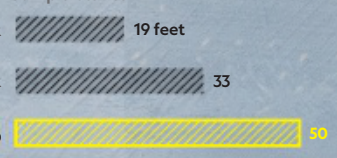
Large nostrils and wide nasal cavities make it easier to inhale large amounts of thin, oxygen-poor air.



HIGH-ALTITUDE COMPANY

A modified gene in snow leopards is thought to produce more blood vessels in the lungs to extract extra oxygen. A similar mutation has been found in wolves and humans living on the Tibetan Plateau.

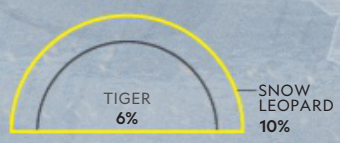
Jump distance



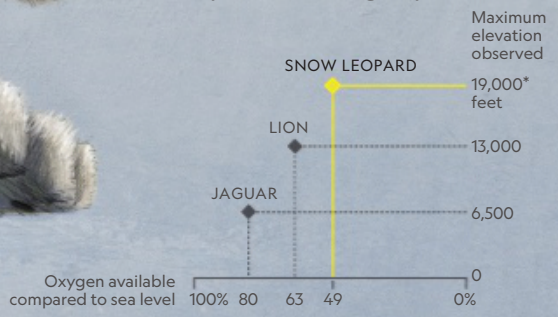
PROTECTIVE PAWS

Large paws act like snowshoes, distributing weight and keeping the cats from sinking into deep snow.

Paw size as percent of body size



Big cats range from sea level to mountain forests, but only snow leopards inhabit the highest peaks.



A camera trap catches the old male snow leopard on a mountain overlooking the Spiti Valley. Photographer Prasenjeet Yadav observed this cat for two years before its death in March, when it chased an ibex off a cliff.

PRASENJEET YADAV

Leopard Trust estimates that 3,500 to 7,000 snow leopards are on the planet, but Charu acknowledged that's just an educated guess. "We've been able to study 1.5 percent of snow leopard habitat. We can't really say how many there are."

What is clear, Charu said, is that in many places where conservationists are studying snow leopards, the cats face mounting threats—poaching, mining that destroys their habitat, retaliation from herders, the disappearance of their prey. "The successes in Spiti and other places are gratifying," he said. "But we need more of them."

AS THE OLD MALE LEOPARD TRIED TO TAKE DOWN THE AREA'S BIGGEST IBEX, **THEY HURTLED OFF A CLIFF, FALLING HUNDREDS OF FEET INTO A GORGE.**

Prasenjeet and I hiked up a mountain pass in the early morning sun, which made the snowy landscape glitter like it was sown with diamonds.

Namgyal, a local guide who helps with the camera traps and goes by a single name, plowed ahead of us through a fresh mantle of thigh-deep snow. It was well below freezing, and I was wearing a wool T-shirt, a hoodie, a flannel shirt, and a wool sweater, all under a down jacket. I moved through the snow like a fat penguin. Namgyal, on the other hand, appeared to be wearing three layers at most, including a down jacket with a fraction of the feathers it once held. But he didn't seem to notice the cold and advanced efficiently through the snow like, well, a snow leopard.

We were headed to some cliffs where Prasenjeet has set up three cameras, which he believes offer the best chance to capture a photo he's been after all winter: a female with three cubs.

When it comes to India's big cats, Prasenjeet, 31, has special insight. He grew up on a farm set among the jungles of India's central plains, near Pench Tiger Reserve, one of the places said to have inspired the setting for Rudyard Kipling's *Jungle Book*. He learned from a young age to recognize the pungent scent of common leopards and discern their shapes among the shadows of the forest. "We never named our dogs," he told me. "Every six months a leopard would eat them." In college, his friends would teasingly call him Mowgli.

When he arrived in Kibber in 2018, Prasenjeet spent long days exploring and patiently learning from the locals, much like Charu. Soon he began seeing the old male. He photographed him stalking ibex and blue sheep and observed him feed on his kills. He followed his tracks, examined his scat, found caves with his scent marks and fur. And thanks to a video camera trap, he'd stared into the leopard's piercing, turquoise eyes.

In the spring of 2019 Namgyal saw the old male mating with a female on a high ledge. In late summer, she had given birth to three cubs, and ever since, Prasenjeet had been obsessed with getting intimate images of the mother and her offspring.

We crossed over the mountain, descended into the next valley, and ascended a ridgeline. From there we scrambled up a rocky band of ledges that offered wide views of the Spiti Valley. "This is like a snow leopard highway," Prasenjeet said, explaining how the cats use the ledges to traverse between the high pastures where their prey come to graze. As if on cue, we saw the heads of several blue sheep peering down at us from atop the cliff.

Immediately, Namgyal found recent tracks, including a small one that might have been made by a cub. Prasenjeet located a fresh urine stain, where a cat had marked its territory. Snow leopards had wandered past all three cameras. But one by one, as Prasenjeet checked the memory cards, our hopes were dashed. One of the traps' batteries had died—a regular problem in the extreme cold. Another's flash had malfunctioned. The last had captured images, but only of an inquisitive fox and a flock of yellow-billed choughs.

Prasenjeet pulled off his fleece hat. Steam rose into the frigid air as he ran his fingers through his long, matted hair. I sensed how weeks of

mind-numbing cold, arduous treks, and the uncertainty of the task had worn on him. He sighed. "The good news is we know the snow leopards are here."

We got back to the village after sunset. It was snowing, and the electricity had gone out. When we saw Thinley, his eyes were wide with excitement: The old male had tried to take down the biggest ibex in the area, but during the chase the cat and its prey went over a cliff and hurtled several hundred feet into the Spiti River.

The next morning we found a crowd of tourists arrayed along the snow-draped edge of one of the deepest parts of the gorge.

Namgyal handed me a pair of binoculars, and there, some thousand feet below, lying in the icy Spiti River, was the carcass of a large male ibex. The current splashed around its body and massive horns.

A guide who saw the kill described how the snow leopard had chased the ibex down the cliff, leaping back and forth between ledges. The cat lunged for the ibex's throat, and they both tumbled out of view. "I heard them crashing, and then I saw them in the river," he said.

Both animals survived the fall, and the ibex had thrashed in the icy water and nearly escaped. But the snow leopard managed to bite the animal's muzzle and hold it underwater until it died.

The ibex was a large male—perhaps 250 pounds, compared with the snow leopard's 80—from a herd often seen near Kibber. "We always see him," Namgyal said. "He had lost his fear."

The carcass was too heavy to pull out of the river, so the snow leopard, trying to stay dry, crouched on top of it and began stripping meat off the rib cage as the sun fell behind the mountains.

The guides knew the cat would feed on the kill for days, so they roused their clients early to claim the best vantage spots from which to take photos. Several set up camping chairs on packed snow perilously close to the edge. "If one person slips, he could knock them all off," Prasenjeet muttered.

The cat had returned to the ibex briefly at first light but suddenly retreated into the rocks out of sight. Some of the guides said he seemed to be limping. Hours passed as we waited for his return. Tourists mingled, guides brought food from the village, thermoses of chai were shared. A bearded vulture floated overhead. Namgyal pointed out a fox scurrying among the rocks.

Late in the afternoon, we learned that the forestry department had caught a tourist who'd sneaked down into the gorge to film the cat without a permit. "That's probably why the cat hasn't come to feed," Prasenjeet said. "It was spooked."

With the sun about to set, most of the tourists returned to the village. Prasenjeet, Namgyal, and I were about to pack up when a guide pointed to the carcass excitedly: The cat was back on the kill.

For a few minutes, just before shadows enveloped the gorge, I watched through binoculars as the old male stood on the dead ibex. He tore at it hungrily. At one point he looked up, as though he sensed he was being watched. I know it's unscientific to anthropomorphize, but I couldn't help but imagine his satisfaction: Think I'm too old to hunt? I just took down the biggest ibex in the valley.

A WEEK AFTER I left India, Prasenjeet called me. He'd traveled down the valley to get a cell signal because he wanted me to know the old male had died. A guide had seen him chase another ibex and then disappear off a cliff. This time he didn't survive. Namgyal helped the forestry department recover the body. Prasenjeet's voice was heavy as he described watching the necropsy. "Its spine was broken," he said. "It was also malnourished, probably starving." He guessed that the cat hadn't eaten enough of the big ibex before the meat froze, forcing him to hunt again.

People from the village came to see the snow leopard cremated. A storm had swept through the valley, dumping heavy snow and signaling spring was still weeks away. They warmed their hands over the pyre. The old male had been a favorite, especially among the guides, because he'd been relatively easy to find. This year every tourist who came to Kibber saw a snow leopard. But in the days after the old male died, no one saw one. Still, the female and her cubs were somewhere, and Prasenjeet planned to find them. ▯

Peter Gwin is a *National Geographic* editor and hosts the podcast *Overheard*. Based in Bangalore, India, **Prasenjeet Yadav** photographed bridges made of tree roots in the December 2019 issue.

THE ROOF OF THE WORLD ISSUE

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JULY 2020

A NEW WINDOW INTO THE WEATHER

BY **FREDDIE WILKINSON** PHOTOGRAPHS BY **MARK FISHER**

They set out to install the world's highest weather station to give scientists unprecedented data on storm-shaping winds and climate change. During their exhausting journey on Mount Everest, they set up five stations at various elevations—and were reminded that nothing ever comes easy on the world's tallest mountain.

NATIONAL ◆ GEOGRAPHIC

At dawn a team of climate scientists and Sherpas from the National Geographic and Rolex Perpetual Planet Everest Expedition assemble the world's highest weather station, at 27,657 feet, on an icy Everest perch known as the Balcony.

MARK FISHER

The lights of Base Camp sparkle at the foot of Mount Everest while the headlamps of climbers form a light trail, revealing their progress up through the Khumbu Icefall, which is safest during subfreezing nighttime temperatures.

MARK FISHER

THREE MOUNTAINEERS CONFERRED on the Southeast Ridge of Mount Everest as dawn broke over the Tibetan Plateau. More than a mile below, the sun's rays illuminated a band of clouds that was feathering the flanks of the mountain with snow.

The men, wearing thick down suits, oxygen masks, and headlamps, hardly noticed the view. They were on a short clock, limited by the amount of oxygen they carried and the possibility that the notoriously fickle weather could suddenly turn against them. Already they'd been delayed by crowds of climbers who'd stormed up the Nepali side of the mountain, hoping to summit that day in late May 2019. But the men couldn't worry about that now. They went about their work with the exaggerated

EXPEDITION EVEREST
Watch scientists attempt to build the world's highest weather station. This one-hour special airs June 30 at 10/9c on National Geographic.

Inka Koch, a glacier hydrologist, retrieves a snow sample near the summit of Lobuche, a peak close to Everest. She and the team gathered more than a hundred snow and water samples on Everest and throughout the Khumbu region, allowing scientists to assess the chemical makeup of the area's natural water supply.
ERIC DAFT

deliberateness of astronauts, methodically unpacking tools and instruments and following a meticulously choreographed plan to erect the world's highest weather station.

As they worked, one of them, Baker Perry, felt a growing pang of fear as he rummaged through the team's backpacks and then frantically searched them again. Two small but key pieces of the station—a pair of one-inch aluminum tubes that attached the wind sensors to the station's central mast—were missing. Perry and his teammates, Tom Matthews and Panuru Sherpa, stared at each other, all three simultaneously turning over this fact in their oxygen-deprived brains and searching for a solution.

Matthews and Perry, both climate scientists, had spent months preparing for this moment. Their team had designed and engineered many of the components of the seven-foot-tall, 110-pound structure to withstand the extreme cold and hurricane-force winds it would face on the highest point of the planet. They had tested the design in the United States and Nepal and then painstakingly practiced erecting it with their climbing leader, Panuru Sherpa, and his crack team of guides.

The reason for this risky and costly expedition was to fill in some critical blind spots for scientists, who lack consistent data from high altitudes. One of these blind spots is wind,

This article was supported by Rolex, which is partnering with the National Geographic Society to shine a light on the challenges facing the Earth's critical life-support systems through science, exploration, and storytelling.

an essential weather variable. At 29,035 feet (8,850 meters), Mount Everest is among the few peaks tall enough to pierce the subtropical jet stream—one of the narrow bands of powerful winds that circle the globe, influencing everything from storm tracks to agricultural growing seasons. Another blind spot is the snowfall patterns that sustain the massive glaciers above 5,000 meters, or about 16,400 feet.

They had built and lugged the devices that would reveal these mysteries to the roof of the world—they were standing in the jet stream's path—but they had no way to attach the wind sensor.

Matthews and Perry had come to Everest as part of an ambitious scientific assessment of the mountain.

The two-month National Geographic and Rolex Perpetual Planet Everest Expedition involved 34 scientists conducting fieldwork at various elevations on the mountain as well as across the neighboring Khumbu Valley. The group included geologists, glaciologists, biologists, geographers, and climatologists.

"This is a new window into the planet," said Paul Mayewski, director of the Climate Change Institute at the University of Maine and leader of the expedition. "We believe the best way to do science on Everest isn't just to do one kind of science but do many kinds of science."

Under Mayewski's guidance, Matthews, 32, and Perry, 44, partnered with Panuru Sherpa, 53, and a team of local guides to open a new scientific window on the summit. In addition to two automated weather stations around Base Camp (at 17,290 feet), the group hoped to install three stations at succeeding elevations—at Camp II in the Western Cwm (21,207 feet), at Camp IV on the South Col (26,066 feet), and at the summit. The stations would transmit the data to a computer server in the U.S., and the data eventually would be shared with scientists worldwide.

"Climate change operates differently in different parts of the world," Mayewski, 72, told me one afternoon as we sat in the communications tent at Base Camp. "This is one of the faster warming continental regions in the world, but we don't know what's really going on above 5,000 meters [16,400 feet]," he said.

The majority of glaciers in high-mountain Asia begin above 16,400 feet. Each year the snowfall in high-altitude basins, along with rainfall at lower elevations, replenishes the glaciers, which ultimately provide water for tens of millions of people in Asia. Yet there are few sources of reliable meteorological data from these altitudes to help researchers predict long-term effects of climate change on the region.

Very few observations exist from the places snow accumulates on Himalayan glaciers, Matthews said. "Once you get above 20,000 feet, as far as I'm aware, there's only been a few weather stations operating in the Himalayas, and none operating at the time we put up ours."

But conducting "meaningful field science," as Mayewski put it, at such altitudes presented myriad challenges. Above 26,000 feet, humans are starved for oxygen, and their fine motor control and high-level decision-making abilities are impaired, making even simple tasks like strapping on crampons slow and difficult.

"Mountaineers are just hoping to summit, take a few selfies, and then get down as quickly as possible," said Pete Athans, a seven-time Everest summiter and the climbing leader on the National Geographic team. Building a weather station "is like stopping on the summit and trying to assemble a car."

To design and install the stations, Mayewski had enlisted Perry, a tall, taciturn climate scientist from Appalachian State University, and Matthews, a quick-talking English climatologist from Loughborough University.

"You can't really make a bulletproof station," Perry said. An Italian research team installed a weather station at the South Col a decade ago, only to have it destroyed by small stones picked up by the wind and blasted like shrapnel into the equipment. Perry and Matthews ultimately worked with the engineering firm Campbell Scientific to help design their stations.

"The two biggest challenges are: one, engineering a tripod that is light enough to make it feasible to carry up but that's also strong enough to survive what could easily be 200-plus-mile-an-hour winds up there, and two, communications," Perry said. Each station's solar panel

SOREN WALLJASPER, NGM STAFF. SOURCE: TOBIAS BOLCH, UNIVERSITY OF ST. ANDREWS

and battery system would need to generate enough power to transmit data via a satellite link.

The product, made of aluminum tubing with steel footings, resembled the love child of a rooftop antenna and a miniature electrical transformer. And after months of practice, the team could assemble and bolt it into rock in less than 90 minutes. But could they pull it off at 29,035 feet?

SCIENTIFIC FIELDWORK AT SUCH ALTITUDES IS ESPECIALLY DIFFICULT. **YOU'RE STARVED FOR OXYGEN AND LOSE SOME ABILITY TO FUNCTION.**

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A NEW WINDOW INTO THE WEATHER

WHEN THE TEAM ARRIVED at Base Camp in mid-April, they joined a record number of mountaineers hoping to cross the world's highest peak off their bucket lists. Nepal's ministry of tourism had issued 382 climbing permits and 390 support permits for Sherpas and guides—meaning there would be hundreds of people all crammed onto the same narrow route to the summit. And they all would be trying to do this during the few good weather days that typically arrive in late May.

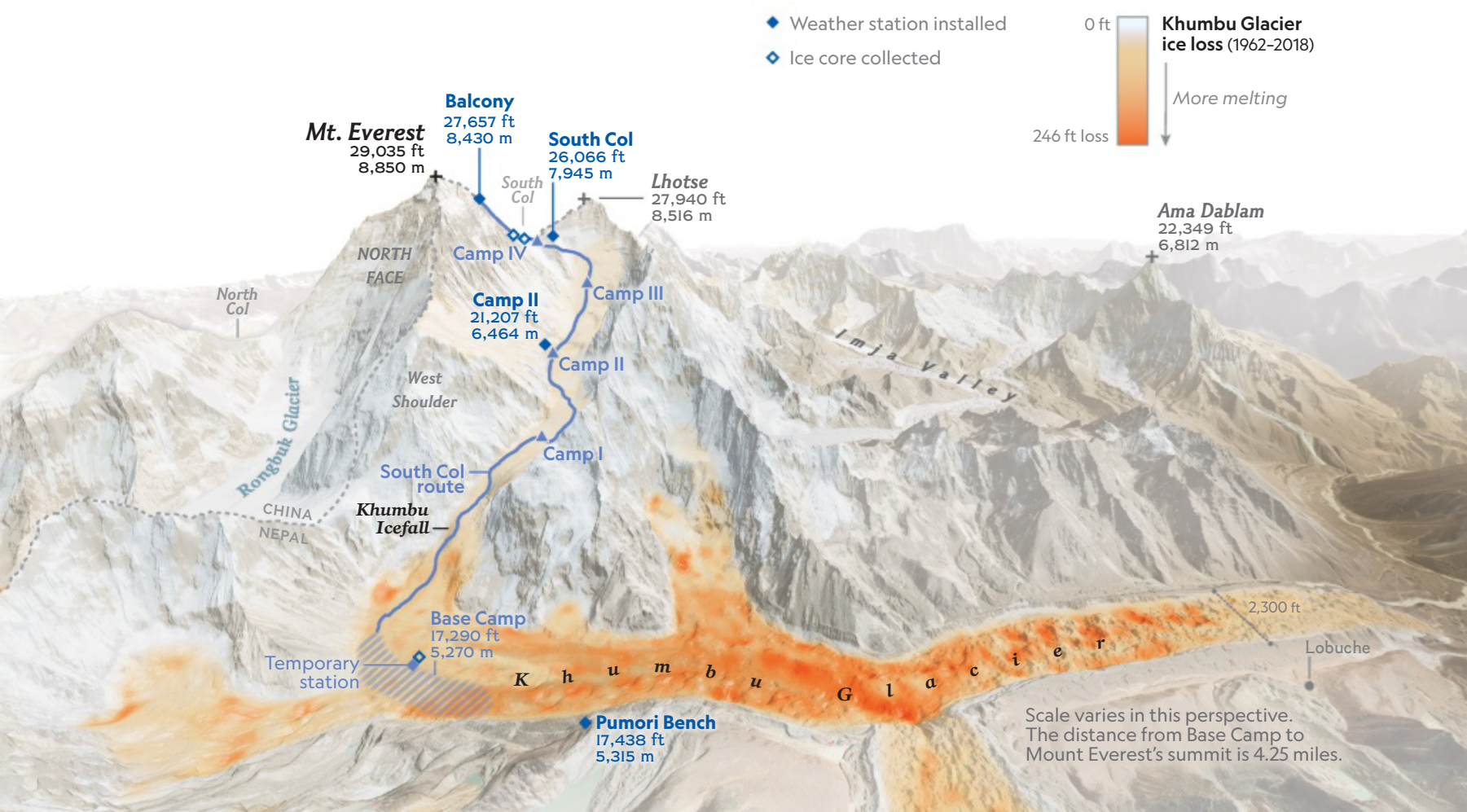
"You have to avoid self-inflicted wounds on crowded days, like taking too long and running out of oxygen," Athans told me. On the other hand, he noted that if the team tried to reach the summit on a marginal weather day, they might encounter fewer crowds but find conditions too unrelenting to install the station.

By May 18 the team had assembled three of the weather stations, with only the last two, set for the South Col and the summit, to go. Forecasts predicted the winds would subside high on the mountain in a couple of days, so Matthews, Perry, and their team of climbing Sherpas led by Panuru packed up and departed Base Camp for the four-day climb to the South Col.

Initially things went according to plan, and on the morning of May 22, the team installed the South Col weather station. They made camp to get some rest and check weather models for the next day. "We had two conflicting forecasts,"

SCIENCE ON HIGH

A team of 34 scientists journeyed to Everest in 2019 to collect ice and snow samples and build a series of weather stations that will give scientists critical new data on how climate change is affecting the roof of the world. One unsettling finding: The Khumbu Glacier has lost nearly a fourth of its volume—about 87 billion gallons—since 1962 due to ice melt.



To ascend the Khumbu Icefall, mountaineers must navigate a dangerous obstacle course of shifting ice formations. Climbers rely on spiked crampons strapped to their feet and follow a path of fixed ropes placed by the most experienced Sherpa guides.

DIRK COLLINS

A NEW WINDOW INTO THE WEATHER

Climate scientist Mariusz Potocki (at left) used a special drill to take a core sample of the ice at 26,000 feet on Everest's South Col. His team later hauled some 30 pounds of ice samples down the mountain. Similar to a tree's growth rings, layers in the ice contain valuable clues to the site's climate history. Get updates from the National Geographic and Rolex Perpetual Planet Everest Expedition at *natgeo.com/perpetualplanet*.

DIRK COLLINS

Matthews recalled, "and one indicated the winds were going to be more unfavorable."

As late afternoon wind rattled their tent, Matthews and Perry breathed bottled oxygen and somberly considered aborting their summit attempt. But by nightfall the winds had subsided and a new forecast arrived. Panuru tapped on the tent's fly: The climb was a go. A high deck of clouds passed over the mountain as they left the South Col at 11:30 p.m., and it began to snow intermittently, casting everything in a chalky darkness.

"We made good progress off the bat, but then we hit the back of the line," Perry said. A queue of dozens of climbers, some of whom had left Camp IV as early as 5 p.m., had come to a near standstill at a part of the route known as the Triangle Face.

After two hours of stop-and-go traffic, the team reached the Balcony—a flat section roughly 1,400 feet below the summit. "We saw the line of people ahead of us," Perry said, "and realized what we were up against."

As Perry, Matthews, and Panuru evaluated the situation, the inky night ebbed into dawn. Instead of pushing on, they decided to erect the weather station on the Balcony. "We had built the South Col station the day before," Perry said. "Our Sherpa team knew how to do almost everything."

Before the mast could be erected, each tripod footing needed to be bolted to rock using a battery-powered drill. But the batteries were dead due to the cold, so Matthews and two Sherpas, Urken and Phu Tashi, put them into their down suits. "We spent 30 minutes hopping around

like mother penguins, trying to warm them."

Once that problem was solved, they realized the tubes for mounting the wind sensors, two small propellers that measure wind speed and direction, were missing. "We couldn't go down without putting on the wind sensors," Perry said. "So we started brainstorming."

Perry realized that the handle of an aluminum shovel the team had brought was roughly the same diameter as the missing tubes. One of the guides, Lakpa Gyaljen Sherpa, grabbed a hammer and pounded the handle to make it fit. Then Perry wrapped strips of duct tape around it.

"It's a supermodern weather station," said Matthews. "But you look closely, and there's a bunch of duct tape and a fluorescent orange-and-blue shovel handle."

In the months after the team descended the mountain, the five Everest weather stations steadily transmitted data on wind speed and direction, temperature, solar and thermal radiation, barometric pressure, and precipitation, giving scientists a rich, new, data-driven view of one of the planet's most complex weather regions.

Researchers around the world have begun factoring the data into a range of climate and weather models. So far, the most significant—and troubling—revelation concerns how ice melts at high altitudes.

Scientists have long understood that the sun's radiation increases dramatically where the atmosphere is thinner. But few measurements of solar radiation had ever been recorded at these altitudes. Some readings taken from the Western Cwm and South Col stations have equaled or exceeded the solar constant—the power of sunlight before it's filtered by Earth's atmosphere. Under such conditions, significant snowmelt can occur even though the air temperature remains below zero. The principle is similar to using a microwave's radiant energy to heat food.

This is important because most climate models used to predict the amount of lost glacial ice rely only on temperature. "There could be thousands of square kilometers across high-mountain Asia experiencing melt that we didn't know about," Matthews told me recently.

In early January 2020 he began to suspect that data from the wind sensor at the Balcony station were growing unreliable. The directional readings began to cluster around a few values, as if the sensor was being impeded, and the wind speeds were significantly reduced. Then, on January 20, the world's highest weather station went completely dark. "If I had to guess," Matthews said, "I would say it experienced some kind of trauma." He paused. "The only way to know is to go back." ▯

Writer **Freddie Wilkinson** covered the 2019 Everest climbing season for *National Geographic* from Base Camp. Photographer **Mark Fisher** led the film crew that documented the expedition.

INSTAGRAM

AMI VITALE

FROM OUR PHOTOGRAPHERS

WHO

Vitale makes photographs that tell stories about the beauty and interconnectedness of life on Earth.

WHERE

Near Sulina, Romania, where the Danube River flows into the Black Sea

WHAT

A Nikon D4S camera with a 24-70mm f/2.8 lens

As winners of the Inge Morath Award, which honors young women photographers, Vitale and seven others got to spend five weeks following the path of Austrian-American photographer Morath, who captured life along the Danube River. The group converted a truck into a gallery space to display her work. They also took new images to show contemporary life in the places that Morath had photographed in the 20th century. Near Sulina, Romania, Vitale watched this fisherman in a quiet moment.

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Florida Manatee *(Trichechus manatus latirostris)*
Size: Body length, 264 - 387 cm (104 - 152.4 inches) **Weight:** 400 - 1,600 kg (881.8 - 3,527.4 lbs)
Habitat: Shallow, slow-moving water **Surviving number:** Estimated at more than 5,000

Photographed by David Fleetham

WILDLIFE AS CANON SEES IT

Cold is a killer. The Florida manatee is not built to withstand low temperatures, and survives the winter only by finding warm water refuges such as warm springs or industrial effluents. This aquatic mammal lives in both fresh and salt water, grazing on seagrasses and other vegetation. But as it grazes it often comes into fatal contact with watercraft. It is also susceptible to pneumonia, a danger that's increasing as warm water sources disappear due to groundwater pumping and the retirement of power plants.

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.

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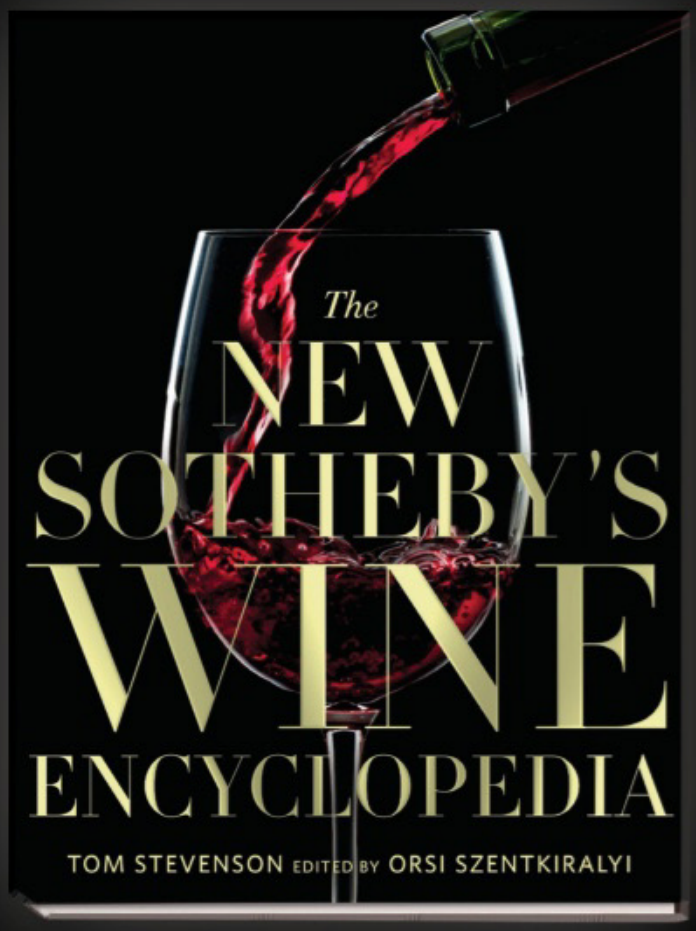

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